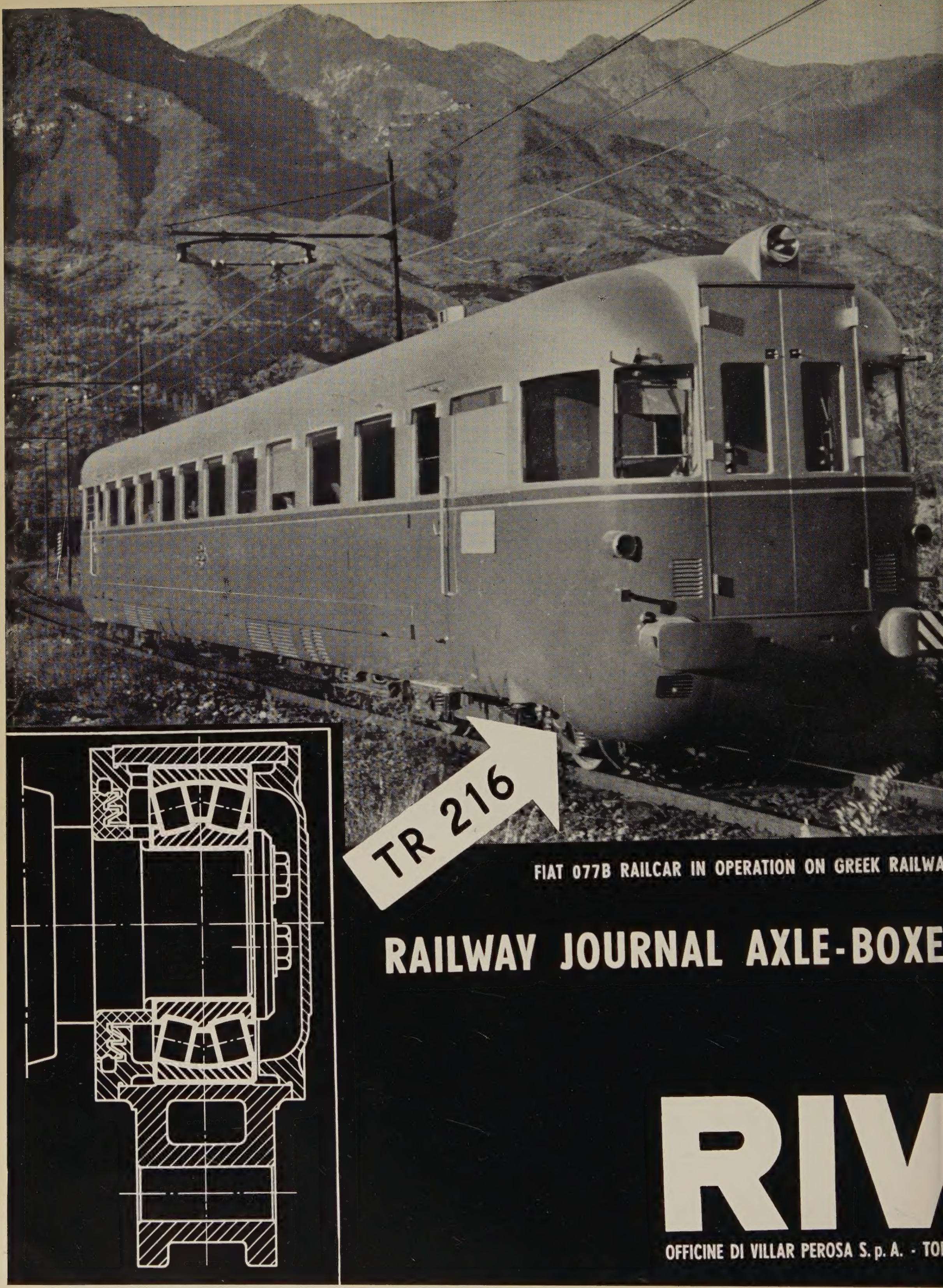
VOL. XXXIV. — No. 4. APRIL 1957.

Monthly Bulletin of the International Railway Congress Association

(English Edition)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Bulletin of the International Railway Congress Association

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES: 19, RUE DU BEAU-SITE, BRUSSELS

Yearly subscription for 1957 : { Belgium . . . . 700 Belgian Francs
Universal Postal Union . . . . 800 Belgian Francs }

Price of this single copy : 80 Belgian Francs (not including postage).

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

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Vol. XXXIV. — No. 4. April 1957.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .142 .4 (43)]

German prestressed concrete sleepers.

A brief history of their evolution,

by Dr. H. Meier,

Professor at the Munich Polytechnic. (*)

During the war (1939-1945) and the following years, there was a great shortage of steel and timber in Germany. There was a great deal of anxiety on the railways as to how future sleeper requirements were to be met. The Headquarters of the Reichsbahn was charged with designing a concrete sleeper technically and economically usable.

* * *

The object of the study was the prestressed concrete sleeper. We were already convinced of its superiority over the other possible solutions.

Other possible designs are :

the ordinary reinforced sleeper;

a mixed type of sleeper consisting of two blocks connected together by a rolled-steel section;

concrete stringers with crossties.

(For the basic considerations on the load bearing capacity of the prestressed concrete sleeper, see the « Remarks » at the end of this article.)

* * *

To save steel, *the sleepers were at first reinforced by rods* (rods highly stressed, reduced weight of steel).

Even before the end of the war, in 1943/44, several thousand sleepers of the B 2 type were manufactured by the Heidelberg Portland Cement Works (small experimental shop) *(figs. 1 and 2)*.

The massive form of these sleepers is due to the difficulties encountered in getting moulds. The sleeper weighs 300 kg (661 lbs.). The normal type of fastenings for track laid on wood sleepers is used (German K type track, also known as Geo superstructure). The coachscrews, four per sleeper, are screwed into wooden bushes.

The B 2 sleeper, in service for twelve years, has stood up extremely well; no deterioration has been noted.

* * *

(*) The Author was Head of the Permanent Way Department at the Headquarters of the Deutsche Bundesbahn from 1943 till the end of 1953.

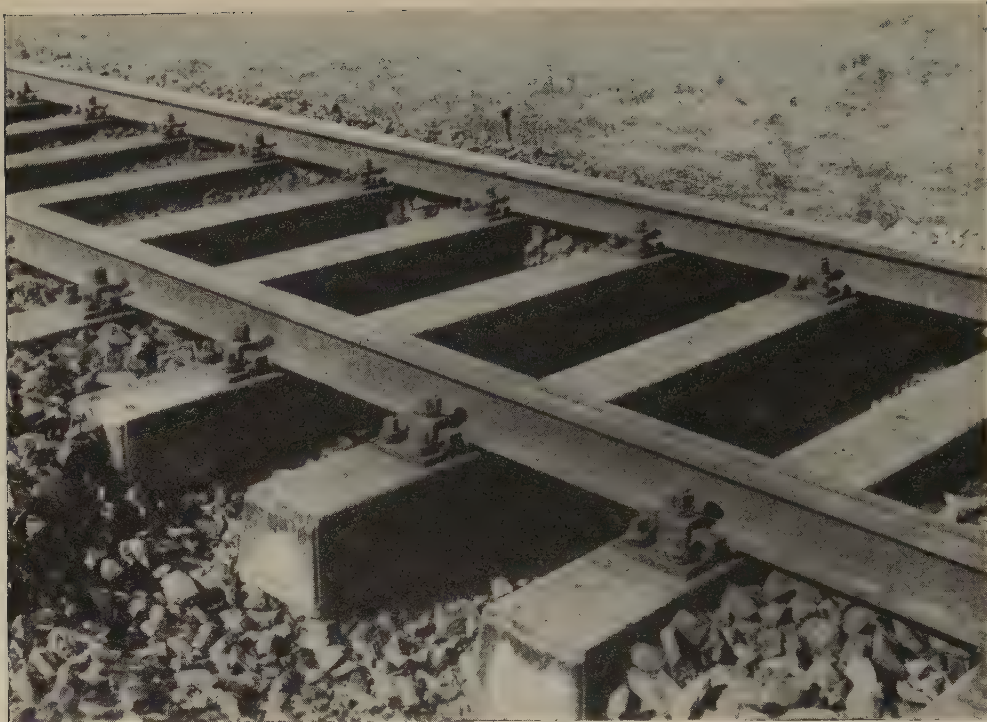
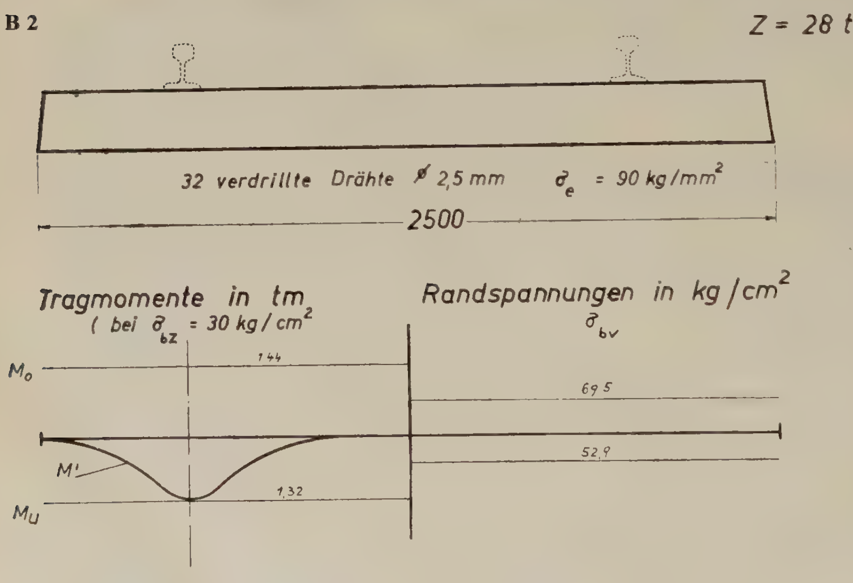
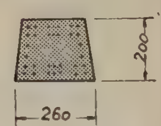


Fig. 1. — Track with B-2 sleepers. (Ballast removed to give a better view.)





As regards the bearing moment to the left: M_0 and M_u are the maximum theoretical moments of deflection without cracks in the concrete body. The sleeper is acted upon by repeated deflections millions of times; the load varying from zero point to M_0 (or from zero point to M_u). M_u is compared with the stress under deflection M', under a rail pressure $P = 15$ t and with normal support (line on the straight).

Z = final total prestressing force. σ_e = *permanent stress in the steel.*

Fig. 2.

N. B. — Verdrillte Drähte = twisted rods.—Tragmomente in tm = Bearing moment in tm. — Randspannungen in kg/cm² = Stresses at edges in kg/cm²

The immediate post-war period was characterised by the search for the most advantageous sleeper from the economic point of view. A great number of different factors had to be taken into account.

In 1946/48, labour conditions were extremely difficult in Germany; fundamental research work was however carried out with the co-operation of first class specialists. (Flow and shrinkage of the concrete in the body of the sleeper under compression; resistance to repeated deflections of the concrete body of the sleeper; influence of cold on the sleeper; stability of the different steels; manufacture of various experimental prototypes, etc.)

* * *

In 1948, the sleeper reinforced with rods was given up because its economic manufacture in large numbers involved very vast industrial installations with large benches for the prestressing. A factory with an annual production of 150 000 sleepers costs about 4 million marks. The Deutsche Bundesbahn at first planned to have six factories manufacturing concrete sleepers. But the firms involved required a guaranteed order

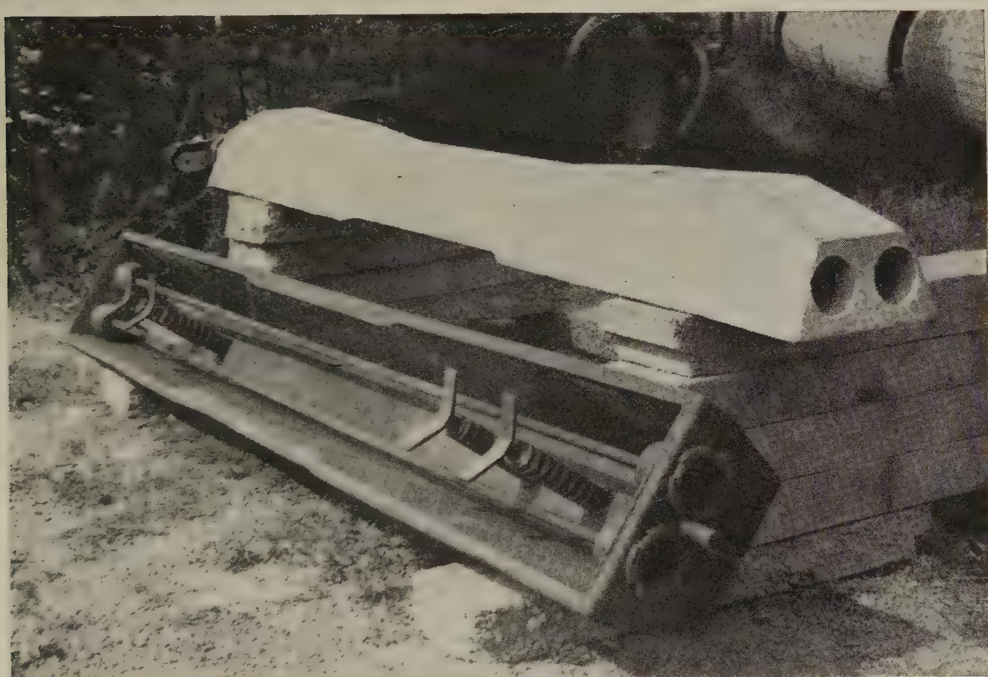


Fig. 3. — View of B 9 sleeper and mould for this sleeper.

covering at least ten years. The D.B. did not wish to commit itself for so long a period.

(1948, year of monetary reform! Money was scarce and dear!)

* * *

In 1948, *the type B 6 and B 9 sleepers* were finally perfected. These sleepers can be manufactured one by one in existing shops; the capital investment required is smaller, and long term contracts are not involved.

The object in view was a cheap sleeper : it must not cost more than a wooden sleeper.

* * *

With the type B 6 and B 9 sleepers, for the prestressing reinforcement silicion spring steel rods are used *(fig. 3)*. These steel rods offer first-rate resistance to great permanent loads. The trials do not reveal any elongation after 1 000 hours under tension close to the limit of elasticity.

The mass of concrete is « free », in other words it is not obstructed with a quantity of rods as in the B 2 sleeper, which has the advantage of making it possible to use a dry mix of large granulometry, which with a proper vibration of the shaker table gives an excellent quality concrete with less cement than previously used. (Strength of the cube after 27 days $\sigma_b > 600$ kg/cm² [8 534 lbs per sq. in.]).

***

In the *B 6 sleeper* there are four smooth prestressing rods connected to the concrete. At the end of each of these rods, there is a special anchorage consisting of an upset end with supporting plates. The prestressing forces, of about 30 t are first of all borne by the mould, which means that strong moulds have to be used. When the concrete has hardened sufficiently ($\sigma_b \geqslant 450$ kg/cm² [6 400 lbs per sq. in.]) the prestressing forces are transferred from the mould to the mass of concrete.

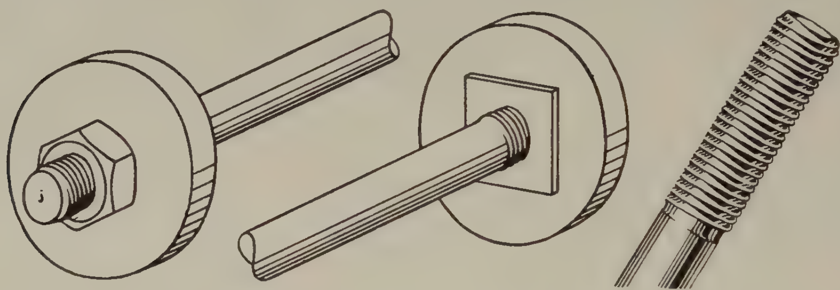


Fig. 4. — Dr. Karig's pretressing equipment. Side where rod is put under prestressing.

In dimensioning these prestressing rods, it must be remembered that :

1) $\sigma_e \leqslant 40$ kg/cm² (568 lbs. per sq. in.) for patent legislation considerations;
2) There is a great reduction in the tension of the steel due to the flow and shrinkage of the concrete (approx. 20 %);

3) There is an increase in the stress in the steel when there is any deflection of the mass of concrete ($\Delta\sigma_e \sim 7$ kg/mm² [4.444 t per sq. in.]).

* * *

The *B 9 sleepers* have two prestressing rods placed in the neutral axis of the concrete sleeper, which eliminates any supplementary stressing of the prestressing steel when there is any deflection of the sleepers. The prestressing rods are coated with bitumin. There is no connection consequently with the mass of concrete. The prestressing rods are first of all put into position unstressed. It is therefore possible to use lighter moulds. The concrete block can be removed from the mould as soon as $\sigma_b = 150$ kg/cm² (2 133 lbs. per sq. in.). Thanks to the faster turnround of the moulds, the number required can be reduced, which results in a considerable saving. The total prestressing force is only applied four to six weeks after the moulds have been removed. It is applied to the hardened concrete. The prestressing can be regulated at any time. As a result, it is possible to make good a large part of the loss of prestressing occurring during the flow and shrinkage of the concrete.

This prestressing method was invented by Dr. Karig. It has the following special features : transmission of the force from the prestressing rods to the mass of concrete through special fastenings (screw with nut and bearing plate). The use of a rolled thread is essential; unlike a cut thread, this does not lead to any reduction in the force which the rod can stand.

Diameter of the rods : 18.6 mm (11/16 in.); $\sigma_e = 45$ kg/mm² (28.57 t per sq. in.) *(fig. 4)*.

The quality of steel used and the dimensions of the rods depend to a large extent on the technique of rolling of the threads.

* * *

During the winter of 1948/49, *large-scale manufacture* began in six factories.

The *B 6 sleeper* is manufactured by the firm: Beton- und Monierbau AG », Dickholzen. The necessary prestressing reinforcements are supplied by the Peine Forges. Although the B 6 sleeper is more expensive than the B 9, its production has been authorised for various reasons.

The *B 9 sleeper* is manufactured by the firms of « Dyckerhoff & Widmann KG » (Hamburg and Neuss); « Wayss & Freytag AG » (Frankfort - on - Main); « Leonhard Moll GmbH » (Munich), and «Thormann & Stiefel AG » (Augsbourg). The prestressing reinforcement required is supplied by the Rheinhausen AG Forges.

Factories manufacturing concrete sleepers have been invited by the D.B. to equip themselves for a monthly output of 10 000 sleepers. However by November 1949, the poor financial situation of the railways obliged them to impose a radical restriction on all orders, which also affected concrete sleepers. Until further notice, purchases are limited to 3 000 sleepers a month per factory instead of 10 000.

* * *

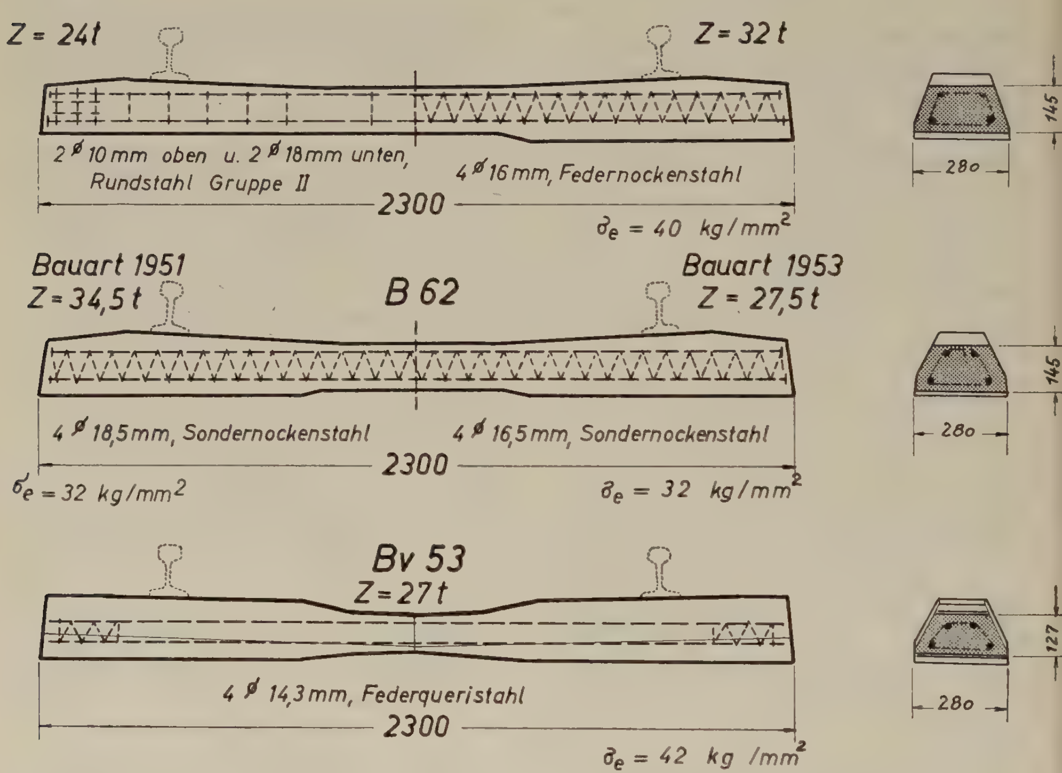
Nearly all the B 6 and B 9 sleepers have been laid on very heavily loaded lines.

* * *

In February 1950, on certain sections of line with very poor subsoil conditions lifting due to frost was experienced and many of the sleepers had cracks in the concrete, always in the top of the middle portion of the sleeper (Exceeding the estimated value of M_{mo}). This phenomenon occurred with both the B 6 and B 9 sleepers. It was judged useful to increase the load borne by the top of the middle portion of the sleeper (M_{mo}).

Remark : It should be noted that at the present time, i.e. seven years later, all the sleepers on which cracks were noticed are still in service on the same lines, without the damage having increased; 90 % of all the B 6 and B 9 sleepers remain free from cracks!

B 6 sleeper **B 61 sleeper**

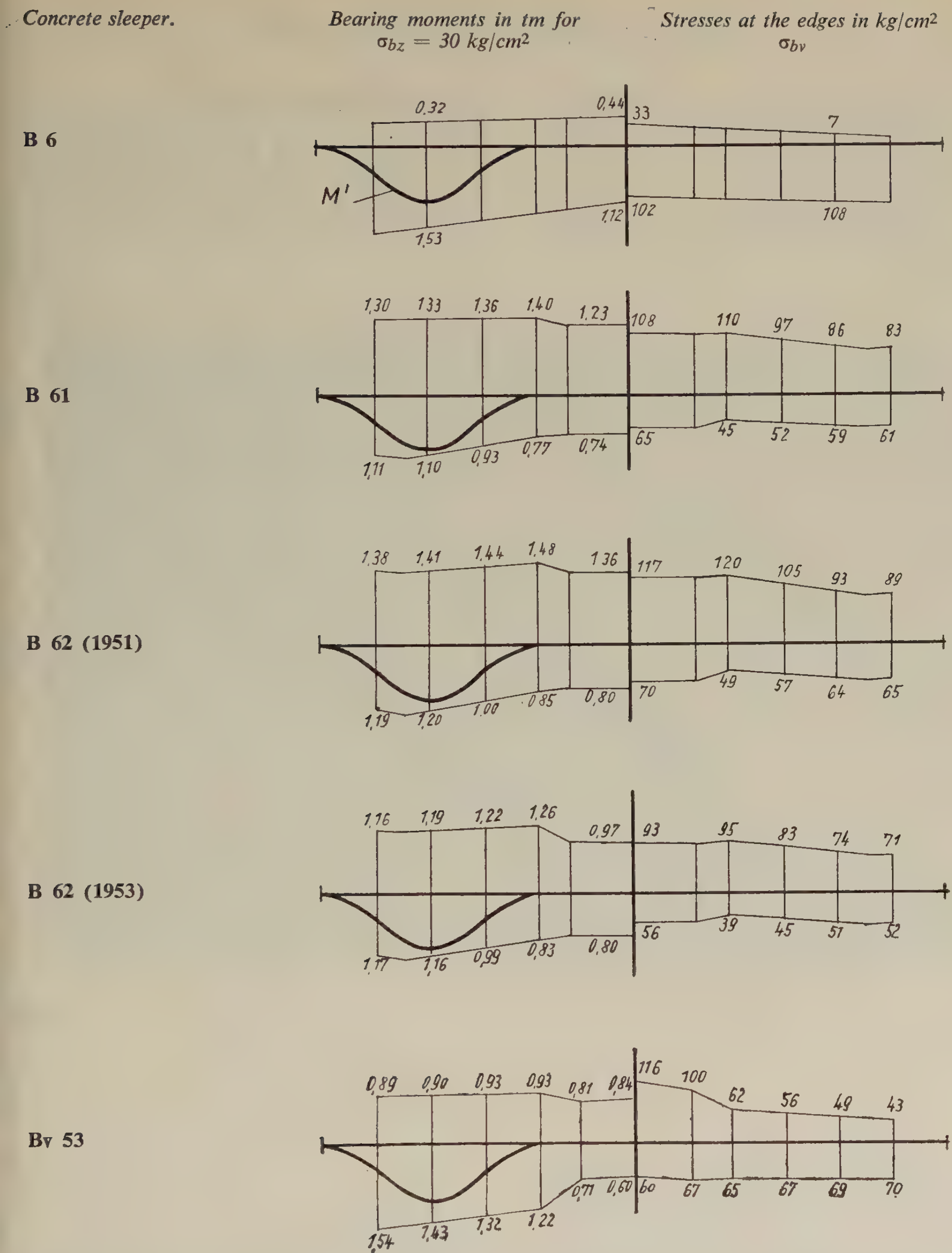


Z = final total prestressing force. σ_e *= permanent stress in the steel.*

Fig. 5.

N. B. — 2 ⌀ 10 mm oben ... = 2 rods of 10 mm above and 2 of 18 mm below, group II round steel. — Federnockenstahl = crimped springsteel. — Bauart = type. — Sondernockenstahl = special crimped steel. — Federqueristahl = spring steel with transverse grooves.

During the years 1950/53 certain modifications were made. These were not



Theoretical bearing load of the different sections of sleepers stressed under repeated deflections, compared with the deflection stress M' under a rail pressure P = 15 t., with normal support.

Fig. 6.

absolutely necessary, but merely of financial interest. These concern :

an increase in M_{mo};

reduction in production costs (new prestressing steels);

reduction of laying and maintenance costs.

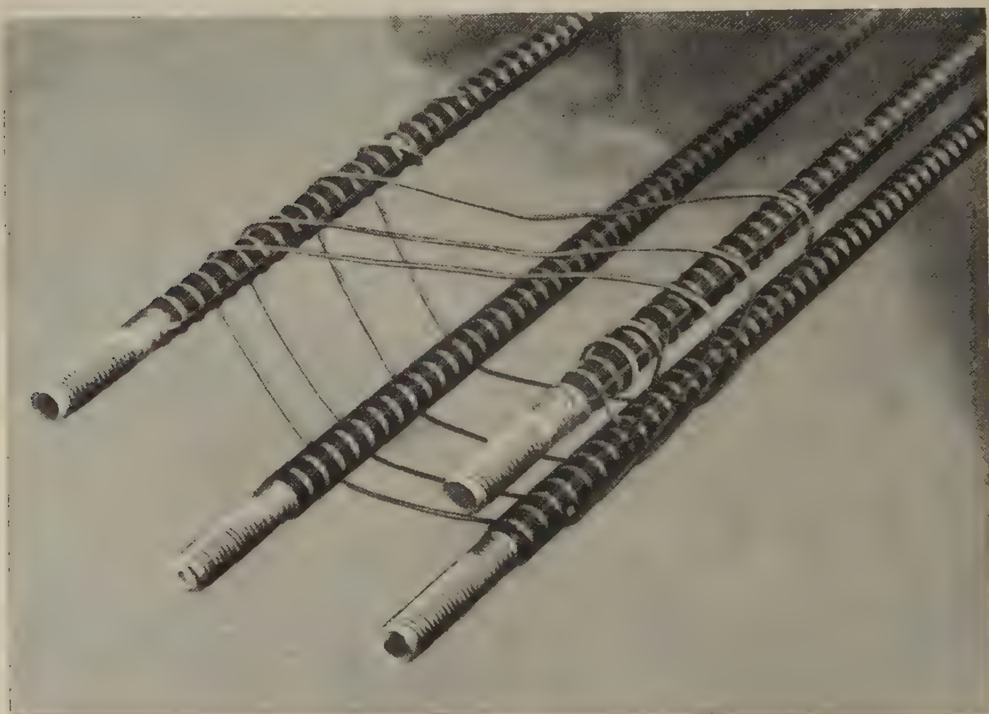


Fig. 7. — The four prestressing rods of spring steel with transversal ribs of a sleeper.

I. *B 6 → B 61 → B 62 (figs. 5 and 6).*

The following were retained :

the mould, and consequently the outer form of the sleeper;

the prestressing method (four prestressing rods connected to the concrete);

the arrangement of the prestressing rods in the mould.

The following were modified :

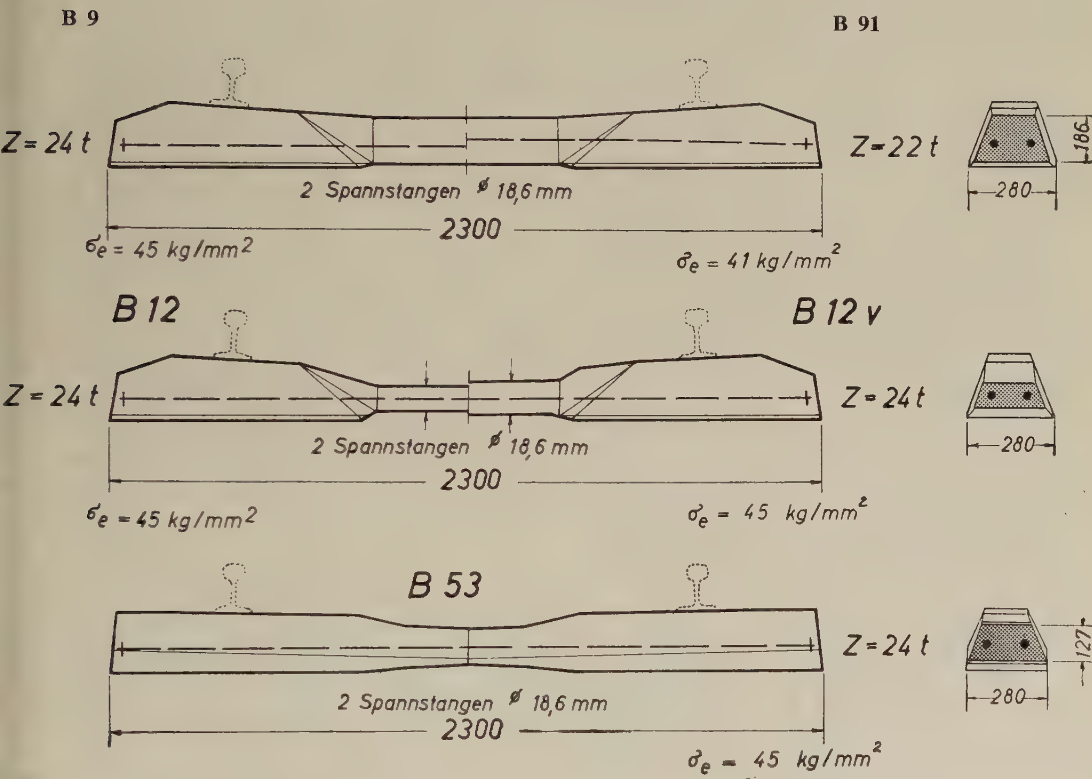
the bottom of the sleeper (This is no longer flat. A slight increase in the thickness of the sleeper in the zone of the rail makes it possible to bestride the central part of the track and thus improve the conditions under which it is supported);

the types and sections of the prestressing rods;

the fastenings at the ends of the prestressing rods.

In the case of the *B 61 sleeper*, smooth round steel is no longer used, but a

crimped steel assuring greater bonding with the concrete. As a result it is possible to do without the upset ends; small screwed bearing plates are all that are necessary. As the only crimped steel available in 1950 was 16 mm (5/8″) dia., reinforced in this way were known as the *B 62 type*. The 18.5 mm (11/16″) dia. rods used at first were however very expensive (high weight of steel); in addition they increased the load capacity of the sleeper to an unnecessary extent



Z = *total final prestressing force.* σ_e = *permanent stress in the steel.*

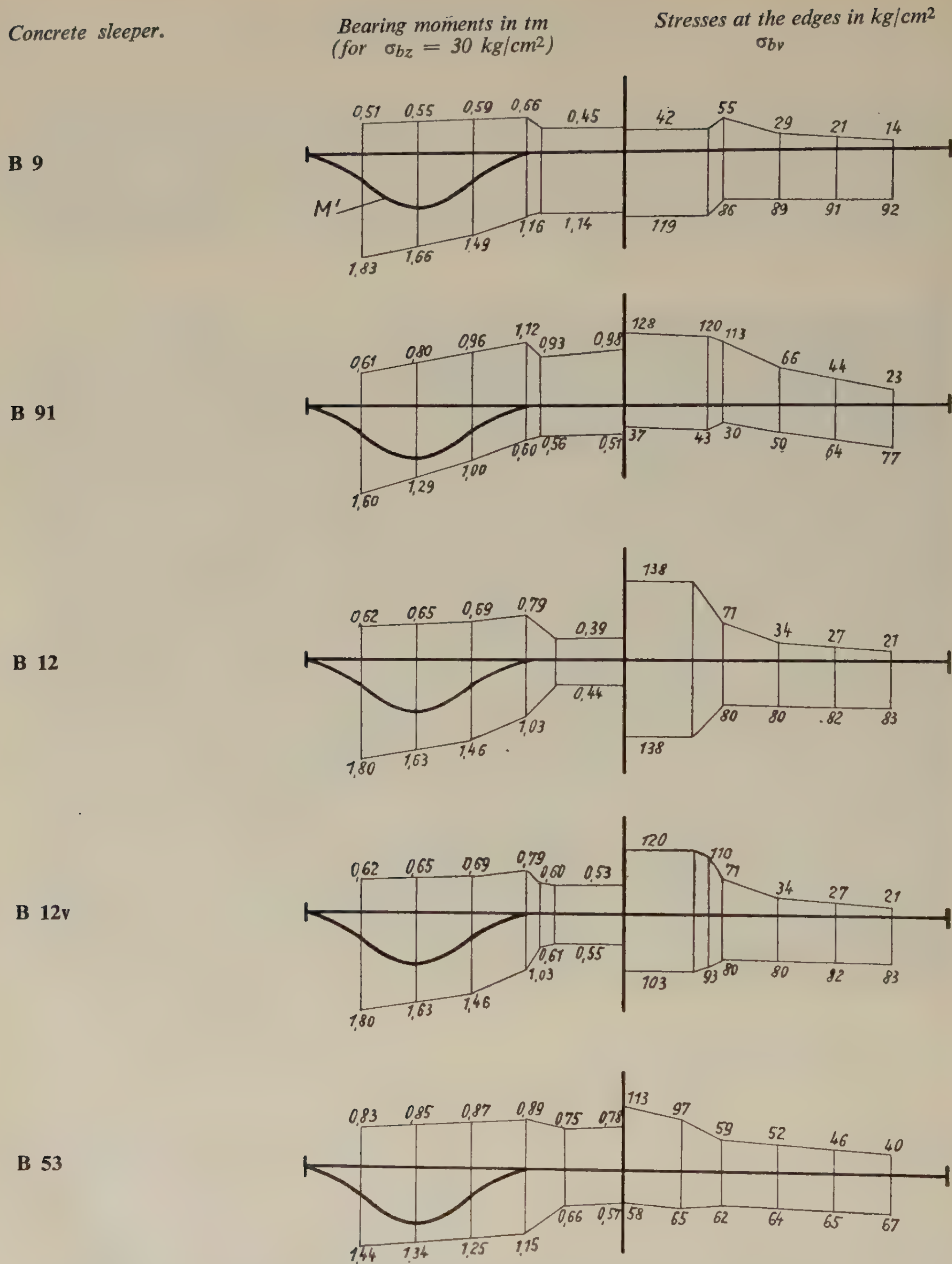
Fig. 8.

N. B. — Spannstangen = prestressing rods.

this was the steel used within its limits of stress.

In 1951 the Peine Forges supplied a new special crimped steel having greater adhesion with the concrete. Under these conditions, it was possible to do away with the bearing plates as well; sleepers (Z — 34.5 t). The D.B. therefore authorised the use of 16.5 mm dia. prestressing rods which with the same value of σ_e (32 kg/mm² [20.32 t per sq. in.]) had a lower prestressing force (Z = 27.5 t).

In 1953, the Peine Forges (Huttenwerk Peine) put a new steel on the market,



Theoretical bearing load of the different sections of sleepers stressed under repeated deflections, compared with the deflection stress M' under a rail pressure P = 15 t., with normal support.

Fig. 9.

known as « spring steel with transverse grooves » which adheres still better to concrete. At the same time certain difficulties due to the laws on patents were solved, with the result that a thinner reinforcement was adopted with more highly stressed four 14.3 mm [9/16″] dia. rods ($\sigma_s = 42$ kg/mm² [26.67 t per sq. in.]) which, with the same prestressing force (about 27 t) cost less (lower weight of steel) *(fig. 7)*.

II. *B 9 → B 91 → B 12 (figs. 8 and 9)*.

Outwardly, there is absolutely no difference between the *B 91 and the B 9 sleeper*. The only difference is that with the type B 91 the reinforcement rods are no longer straight but slightly curved. This is possible because the rods are put into position without tension, coated with bitumin and the prestressing force only applied afterwards. With practically no increase in cost, M_{mo} has been increased by a better distribution of the compression prestressing.

Using Dr. KARIG's method of prestressing, certain initial difficulties still had to be overcome in 1950. This was soon successfully done by the selection of a suitable bitumin, by regulation of the prestressing in winter by means of electric heating, and by determining the influence of the tensile force due to the nuts.

As there must not be any reaction being supported in the middle part of the sleeper, a hollow has to be made and maintained in the ballast. This is sometimes inconvenient.

The *B 12 sleeper* represents progress from this point of view. A rolled and level ballast can be used. The pronounced hollow under the central part of the sleeper makes it necessary to reduce the top to retain the axial position of the prestressing forces. This means that the central part is very thin, strongly prestressed and may have to undergo considerable elastic deflection. The B 12 sleeper is made in the same moulds as the B 9 and B 91 sleepers. It is only necessary to weld on the *fittings*. The same prestressing rods are used as for the type B 9.

The type B 12 is so far the cheapest sleeper. The low value of M_{mo} (or M_{mu}) of the thin central portion of the sleeper is to a great extent compensated by the elastic flexibility of the sleeper. (Smaller bending moment under equal external loading.)

The changeover for the production of the type B 12 instead of the type B 91 is taking place progressively, above all for technical considerations in connection with laying them in the track.

* * *

As far back as 1948, when the types B 6 and B 9 were designed, the question of the resistance of prestressed concrete sleepers to the shocks due to derailment was investigated. Falling weight tests made with two blows of a 500 kg tup dropped from a height of 75 cm (2′5 1/2″) on to the sleeper at a point 25 cm (9 7/8″) away from the rail on a concrete sleeper being laid on a bed of ballast, gave very favourable results in comparison with the ordinary reinforced concrete sleeper.

In 1953, derailment trials were carried out at Gütersloh station (Westphalia), which were made as realistic as possible. In each case the speed of the train haul-

ing the heavily loaded derailing wagon over the 60 m long test section was 50 km (31 miles)/h. One axle of the derailing wagon dropped off the rails onto the track onto concrete sleepers over which it was dragged when derailed.

The results were as follows :

1) A great deal of damage in the case of B 12 sleepers (breakages in the thin, highly stressed, central portion, even when the blow was close to the rail).

2) The B 91 sleepers with two prestressing rods, not connected to the concrete, were less resistant than the B 62 sleepers with four prestressing rods connected to the concrete (the rods are distributed over the angles of the section).

3) The more massive the sleeper and the better it is embedded in the ballast, the less the damage.

4) The derailed axles were deflected transversely by the inclination of the top of the sleeper (one wheel on the ballast, the other in the axis of the track).

The questions which arise are the following :

How many derailments occur each year?

How many sleepers are then destroyed?

How much is the cost of sleepers increased when their resistance to the effects of derailment is increased?

* * *

A financial study was made. In 1953, it was thought that the main cause of derailments was the breakage through fatigue of the axle journals, and everyone was convinced that this cause could soon be eliminated to a great extent by a regular ultrasonic examination of the axles (discovering the beginnings of cracks in good time). These optimistic views conditioned the decisions taken.

The type B 12 sleeper was simply slightly modified in the central part. The modified type was called B 12v. No modification was made to the B 62 sleeper.

Under no pretext should the price of the concrete sleeper be increased, as towards this period the German suppliers of wooden sleepers (The Forestry Administration and the wooden sleeper industry) again declared a war against the concrete sleeper and waged it by all possible means. The cost of a non-impregnated beech sleeper fell by about 21 DM to some 13 DM, and that of a beech sleeper ready to lay by about 27 DM to approximately 19 DM. The comparative price of the concrete sleeper was about 27 DM. The wooden sleeper obviously could not long remain at this competitive price.

* * *

Towards the same period, the moulds needed replacing in several factories. The Headquarters of the Bundesbahn designed for the new moulds required the *B* 53 *type of sleeper (fig. 5)*, which is more or less the same as the B 12v. sleeper except that the tops of the sleepers are horizontal. This makes it possible to put the rails on the sleepers very quickly, and in case of derailment, avoids deflecting of the derailed axle.

Two methods of prestressing were authorised as before for the B 53 type sleeper :

Dr. KARIG's process (two bitumin coated prestressing rods), and

the : «Beton- und Monierbau» Company's method (four rods of spring steel with transversal grooves directly connected [B 53v.] *(fig. 7)*.

* * *

In 1953, « Dyckerhoff & Widmann KG » began production with the *stripping or removal from the mould* quick process, which has now been perfected. It was used with Dr. KARIG's prestressing method. The advantage of immediate stripping from the mould lies in the fact that only a few moulds are then required and expensive equipment is eliminated. Any modification of the shape of the sleeper subsequently found advisable can be made at once without any special expenditure.

* * *

In 1953, the production capacity of the six existing factories was increased. Four new ones were built (Dyckerhoff & Widmann KG, at Erbenheim, near Wiesbaden; Beton & Monierbau AG at Langelsheim, near Goslar; Pfleiderer at Neumarkt/Opf; Katz and Klump AG, at Gernsbach, near Baden-Baden). The total annual production of the ten factories working in two shifts, was increased to 2.1 million sleepers.

* * *

By the winter of 1953/54, *three million concrete sleepers* had already been laid, mostly on the most heavily loaded lines of the D.B. *That winter was exceptionally severe.* On sections with a poor subsoil, there was a great deal of lifting due to frost. Certain concrete sleepers showed, as was only to be expected, cracks due to stresses acting transversally to the surface of the middle portion, indicating that M_{mo} had been exceeded. An exact census of all these cracks showed that an average of about 5% of all the sleepers on the lines were cracked, even if extremely

Fig. 10. — Destruction caused by an accident on the line (Cologne)-Sohlingen-Ohligs-Bif of Linden Junction, near Haan station.

fine cracks, which only showed when the surface of the sleeper was damped, were taken into account. The statistics showed that the incidence of cracks varied with the different types. The higher the M_{mo}, the smaller the number of sleepers with

cracks due to deflection. In the case of the B 12 sleeper, which has the lowest M_{mo} value, its elastic flexibility showed itself favourably.

Consequently, it must be expressly stated that the concrete sleepers stood up very well to the great frosts of the winter of 1953/54, and under the excessive stresses due to irregularities in support which had occurred, only showed insignificant deflection cracks and in the proportions foreseen. Such deflection cracks do not affect the value of the prestressed concrete sleeper and will have very little effect upon its service life.

* * *

During the years 1954/55, there was an increase rather than a decrease in the number of *cases of derailment*. The causes of these derailments were usually hot axle boxes that had not been noticed in time. Some of them resulted not only in damage to the concrete sleepers, but appreciable damage to the rolling stock as well as the goods carried, together with a certain risk for the staff. But all things being equal, the damage was not more considerable nor more serious than in the case of derailments on lines with the old wooden sleepers. The fact that tracks laid on concrete sleepers are generally composed of long welded rails gave rise to some concern. The destruction of the sleepers may upset the rigidity of the body of the track, and in summer, the rails which are submitted to compression forces might twist spontaneously. Following vehicles then could be derailed in turn, which would increase considerably the danger *(fig. 10)*.

Observations made have shown that the types with four prestressing rods attached to the concrete (for example B 62) are sufficiently resistant in case of derailment. The derailment trials carried out at Gütersloh have thus been confirmed.

* * *

In 1955, the D.B. required for the continued manufacture of concrete sleepers, a sleeper with a greater resistance to the shocks caused by derailment. In case of derailment, the sleepers should only suffer slight damage. The integrity of the track must be assured.

To profit by experience, it was stipulated :

a) the prestressing reinforcement must consist of at least four rods connected to the concrete, and arranged near the edge of the section, and

b) the central portion of the sleeper must have a more robust form, and be connected by a regular curve with the ends.

The D.B. also stipulated as an essential factor of the new acceptance test that any new type of sleeper must be guaranteed to stand up to shock tests and for this purpose laid down a new test much more severe than the old ones.

* * *

The method of prestressing by means of two rods encased in bitumin, consequently not connected to the concrete, was given up. It must however be stated expressly that sleepers of the B 9, B 91, B 12 and B 53 types, manufactured in large quantities by this process, have stood up well in the track from the point of view of bending stresses.

* * *

B 55

Prestressing reinforcement according to the methods used by the firms :

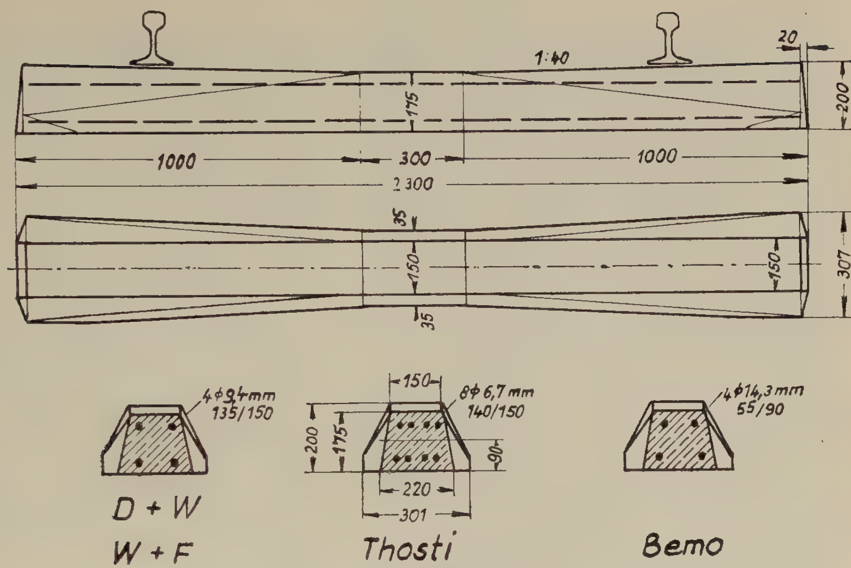
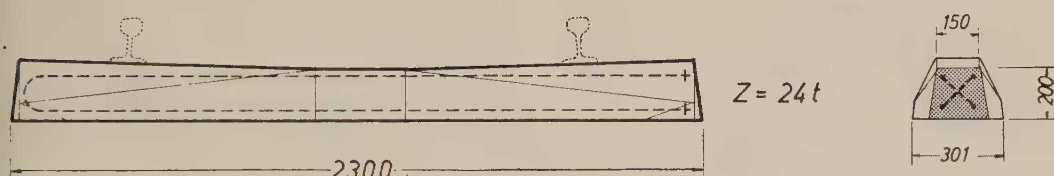


Fig. 11.

B 55



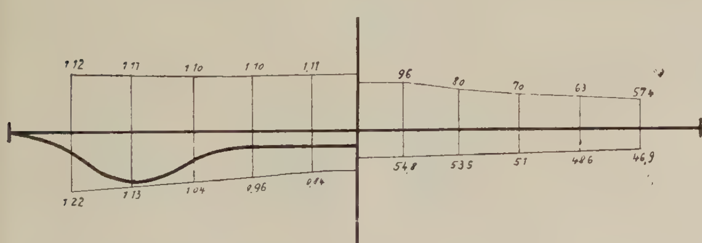
2 rods of hairpin shape of 9.7 mm diameter.

$\sigma_e = 81\ kg/mm^2$

(Sleeper by D & W method)

Bearing moments in tm for $\sigma_{bz} = 30\ kg/cm^2$

Stresses at the edges in kg/cm^2 σ_{bv}



Theoretical bearing load of the different sections of sleepers stressed under repeated deflections compared with the deflection M' under a rail pressure P = 15 t and with normal support (line on the straight).

Z = *final total pretressing force* σ_e = *permanent stress in the steel*

Fig. 12.

The *type B 55 sleeper* was designed and put into service *(figs. 11 and 12)*. Manufacturers were only bound by the shape and carrying load. The type of reinforcement, method of prestressing, and method of manufacture were left to them, though they must observe during manufacture the « Regulations concerning the type of construction, calculations and conditions of acceptance » and « The technical conditions of delivery ».

The following methods, perfected by the firms listed below, have to-day been approved by the D.B. :

1) *Dyckerhoff & Widmann KG method.* — Here four 135/150 (*) steel rods, 9.4 mm (3/8″) diameter are used, and its chief characteristic is immediate removal from the moulds and the subsequent connection.

(The main concrete body, immediately stripped out, has four longitudinal holes made by means of the core rods. When the concrete has hardened, the prestressing reinforcement is introduced into these longitudinal holes and prestressed against the concrete. The prestressing reinforcement consists of two rods of hairpin shape, the curved parts of which cross at one end of the top of the sleeper. The free ends of the prestressing rods are at the other end of the sleeper and are fitted with the screwed fastening. Connection with the concrete is assured subsequently by filling in the longitudinal holes by injecting cement.)

Five factories are now using this method (Hamburg, Neuss, Erbenheim, Neumarkt and Gernsbach).

(*) The figures signify elastic limit and breaking load of the steel in kg/mm^2.

2) *Beton- und Monierbau AG method,* in which four 14.3 mm (9/16″) rods are used as previously, made of spring steel with transversal grooves 55/99, characterised by the immediate making of the connection and the setting up of the prestressing by pressing against the mould.

Two factories are now using this method (Dickholzen and Langelsheim).

3) *Wayss & Freytag AG method,* using four 9.7 mm (3/8″) dia. 135/150 steel rods, characterised by the immediate making of the connection and carrying out the prestressing by pressing against the mould, through special fastenings.

One factory is using this method (Frankfort).

4) *Thormann & Stiefel AG method,* using eight 6.7 mm (9/32″) 150/170 steel rods, characterised by the use of transversal stop devices at the ends of the rods (BBRV prestressing method), the immediate realisation of the connection and the use of prestressing by pressing against the mould.

Two factories are now using this method (Augsbourg and Munich).

* * *

As regards the fastening of the rails to the sleepers, in Germany the following three methods are used :

1) The rail rests directly on the sleeper, through the intermediary of a simple thin rubber pad, and is held by rigid clips the outer wings of which fit into steel grooved pieces sunk into the concrete. The coachscrews are screwed into wood bushes inserted in the concrete; between the head of the coachscrew and the clip, there is

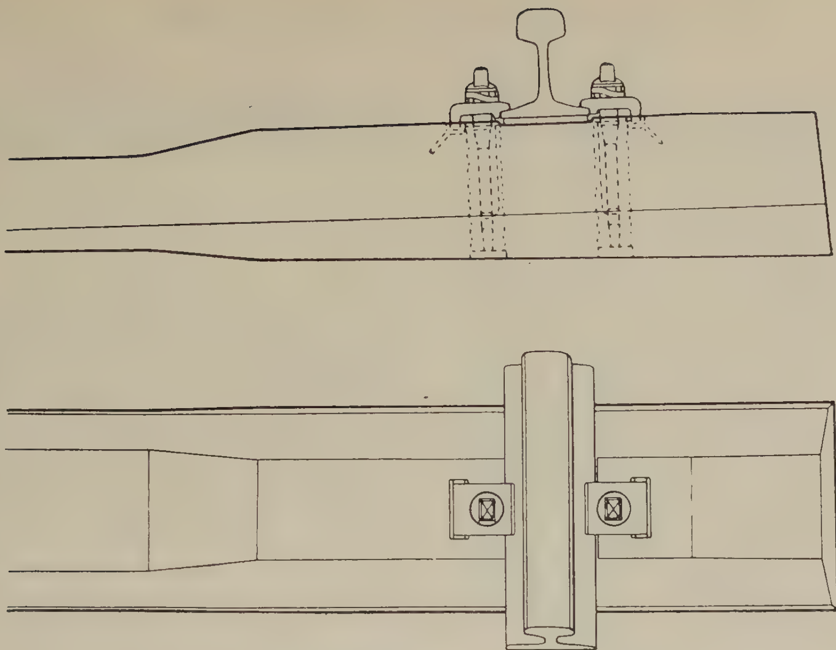


Fig. 13. — Fastening by clips with standard coachscrews.

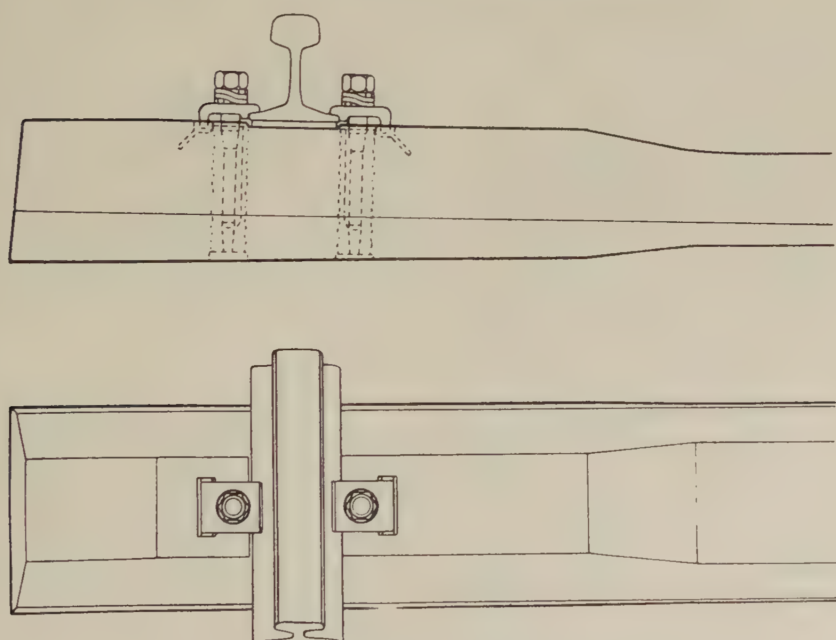


Fig. 14. — Fastening by clips with collar bolts.

an elastic washer intended to maintain the tension *(figs. 13 and 14)*.

This cheap type of fastening is not recommended for lines with many curves and very heavy traffic.

2) Between the rail and the concrete sleeper a steel plate with guiding shoulders is slid *(fig. 15)*. Between the rail and this bearing plate with shoulders, a further pad of compressed poplar is inserted, forming an elastic support. The rail and the bearing plate are simultaneously held in place by so-called collar bolts (Bundschrauben) which in turn are screwed into a wooden bush sunk in the concrete. This type of fastening is definitely more resistant to transversal shock forces than that described under 1) above. Up to the present, it has stood up well in service.

3) Use of a ribbed or grooved bearing plate with a separate fastening of the bearing plate to the sleeper and the rail to the bearing plate *(fig. 16)*.

This is expensive to buy, but it is very robust and capable of standing up to all possible stresses. It guarantees a long useful life and great rigidity of the body of the track.

In future the B 55 type of sleeper will always be laid with this type of fastening.

It can be stated that in principle the wooden bush has behaved very well. It is not costly to buy, is advantageous from the point of view of insulation, and has a long expectation of life (about twenty years). It can be replaced in the line without interrupting the services. Electrical isolation of the sleeper can be obtained economically by means of the wooden bush and a layer of bitumin applied under the ribbed bearing plate (or bearing plate with shoulders). The results obtained to date have not given rise to any unfavourable comment.

* * *

RÉSUMÉ

After the thorough-going preliminary work carried out in 1946/48, the Deutsche Bundesbahn began without any great risk in 1949 to manufacture concrete sleepers in large numbers. In the following years, they gained experienced on a very wide basis and slightly modified the types on several occasions as a result of this experience, making use of the better materials and applying the results of recent research work. The B 55 sleeper appears to be the best solution at the present time for the conditions obtaining in Germany from the technical and economic points of view. With this they have obtained :

a sufficient bearing load from the point of view of deflection;

great resistance to violent derailment shocks;

great rigidity of the frame in combination with a robust type of fastening, and

satisfactory electrical isolation at minimum cost.

This sleeper makes it possible to hope for great safety, long life, and a very favourable cost price compared with other types of sleepers (steel and wood).

The D.B. has not grudged any expense to perfect its concrete sleepers, and is convinced that they are entirely suitable as a component in track construction. It has laid about 5 million concrete sleepers on its lines up to the end of 1955. Accord-

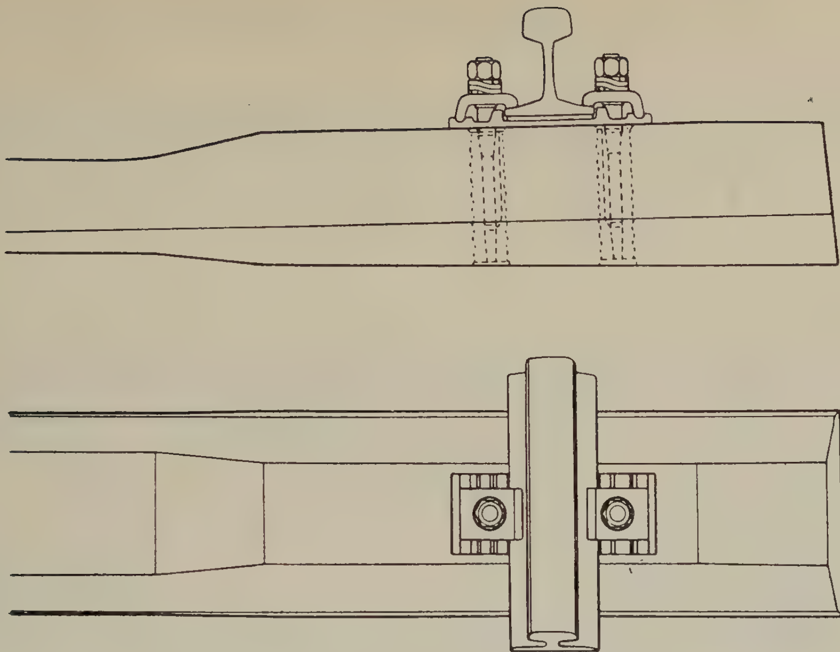


Fig. 15. — Fastening with bearing plate with shoulders.

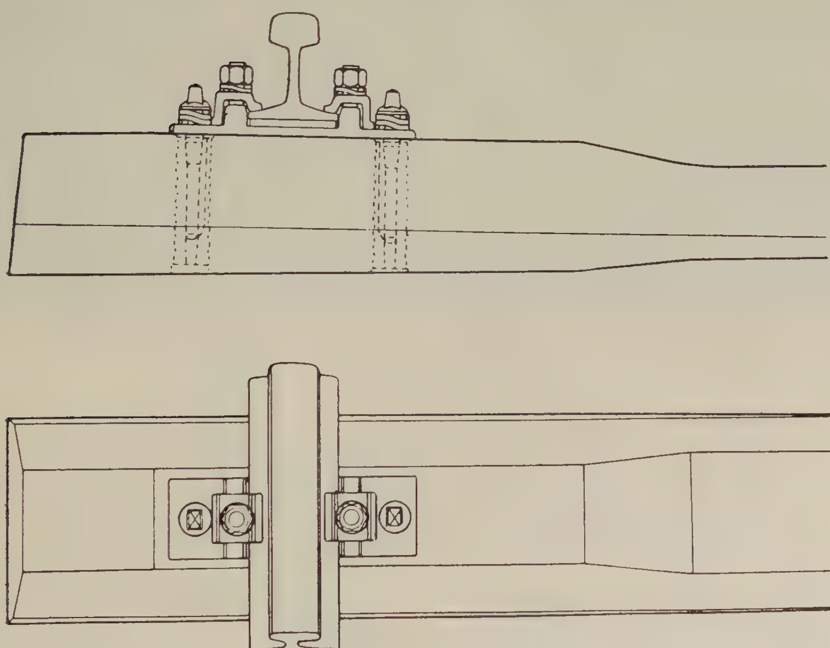


Fig. 16. — Fastening with grooved bearing plate.

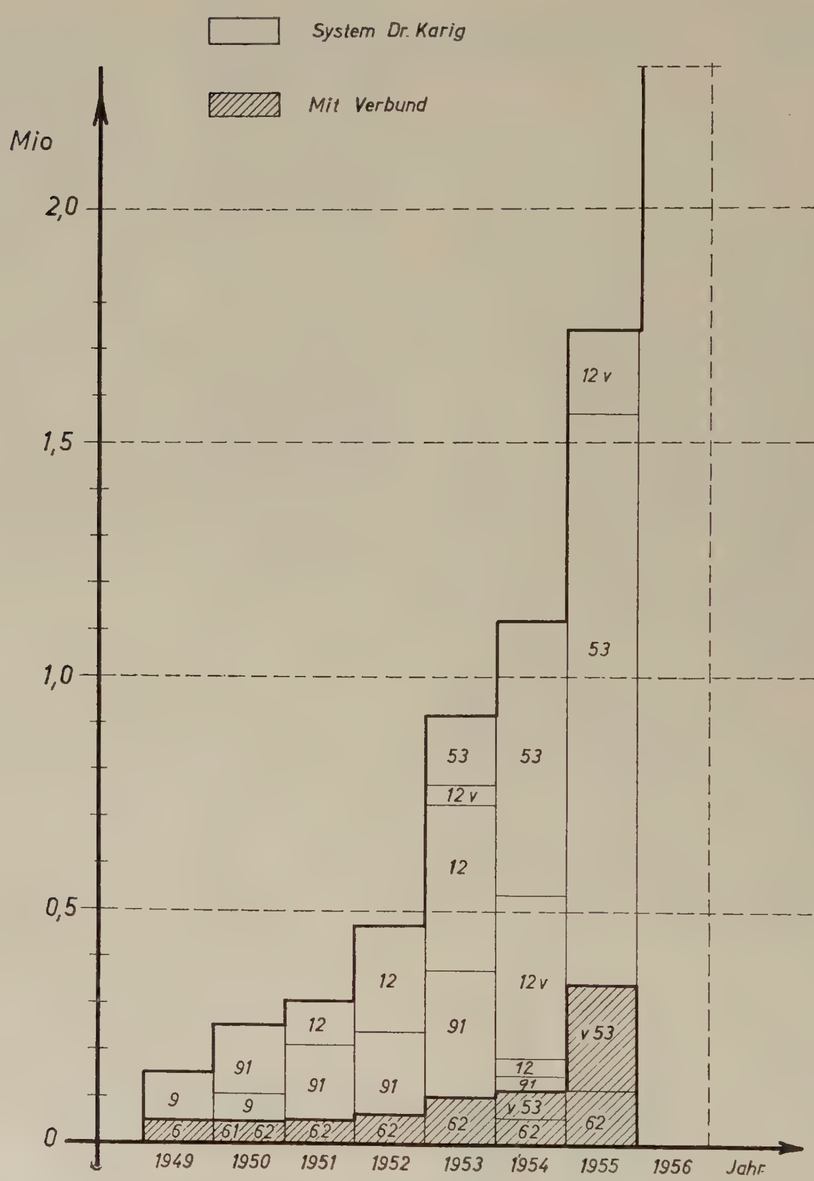


Fig 17. — Quantities of prestressed concrete sleepers manufactured for the main lines of the Deutsche Bundesbahn.

N. B. — Mit Verbund = with connection.

ing to market conditions and the price of wooden sleepers, the D.B. will purchase in the future, 1.8 to 2.4 million concrete sleepers a year, to cover its annual sleeper requirements, which amount to some 3.3 million *(fig. 17)*.

***

Fig. 18. — Concrete sleeper on the Munchen-Lindau line.

OBSERVATIONS

Bearing load and stressing of the prestressed concrete sleeper.

1) The bearing load is determined by the stress *under repeated deflections.*

M = *Bearing moment* = moment of maximum deflection in a given section of a sleeper repeated millions of times in the form of loads varying from zero point to M, which can be supported without cracking the mass of concrete.

M′ = *Moment of deflection* in a given section of a sleeper, produced by the *exterior load* (pressure of the rails and reactions of the support on the ballast).

As a general rule M > M′.

For the calculations, sufficient precision is obtained if

$$\boxed{M = (\sigma_v + \sigma_{bz}) \cdot W}$$

in which

σ_v = Compression prestressing in the edge zone of the section of sleeper;

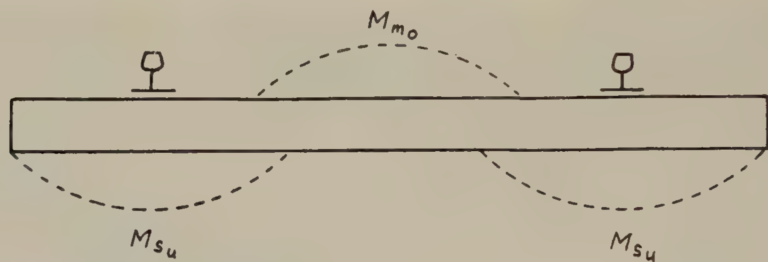
σ_{bz} = Resistance of the concrete to traction under repeated deflection : 30 kg/cm² (455 lbs. per sq. in.);

W = Moment of resistance of the section of sleeper under consideration.

Two transversal sections are particularly interesting to judge of the load carrying capacity of a sleeper :

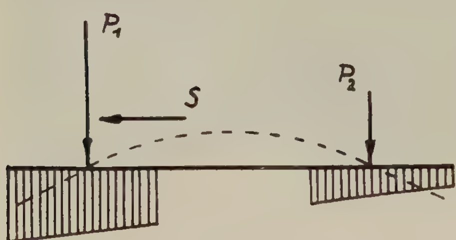
the section under the rail M_s, in particular M_{su};

the middle section of the sleeper M_m, in particular M_{m_o}.



2) *Exterior load under normal conditions of support.*

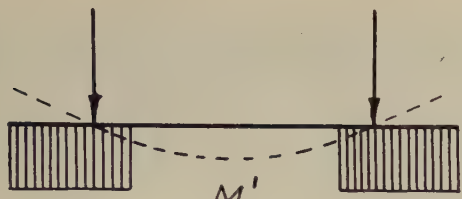
on the straight,



on curves.

Exterior load under abnormal support conditions.

deplacement of the support inwards,



deplacement of the support outwards.

3) *Measures relative to the economic dimensions.*

a) M'_{s_u} *becomes relatively small* when the length of the sleeper is small (2.3 or 2.4 m [7′ 6 1/2″ or 7′ 10 1/2″]); shorter distance from the rail to the end of the sleeper.

b) M'_m becomes very small on straight track when the support under the rail is symmetrical, and there are no support reactions in the middle part of the sleeper. This latter result is obtained by making a hollow in the ballast or giving to the sleepers a special shape.

c) On lines on curves, the transversal stresses applied by the vehicles give a certain value of M'_{m_o}, the maximum of which can be determined approximately theoretically.

d) Variations in support conditions in relation to the theoretical state affect M'_m above all. The existence of very high values of M'_m is imaginable, but is rarely possible. For economic reasons, the dimensions of the sleeper are not based upon $M'_{m_{max}}$; a lower value is estimated and adopted

$$M_m < M'_{m_{max}}$$

The object of the investigation is achieved when in the long run no cracks appear in the mass of concrete on more than 5 % of the sleepers.

e) In a prestressed sleeper, the formation of cracks does not give rise to any disquietude. The crack will always close up again under the effect of compression (the great advantage of the technique of prestressing). As long as the deflection load on the sleeper remains normal, the compression prestressing will not be wiped out in line with the crack and consequently the cracks do not « breathe ». As a general rule, the useful life of the prestressed concrete sleeper is not curtailed, at least to any appreciable extent, by the presence of cracks in the mass of concrete.

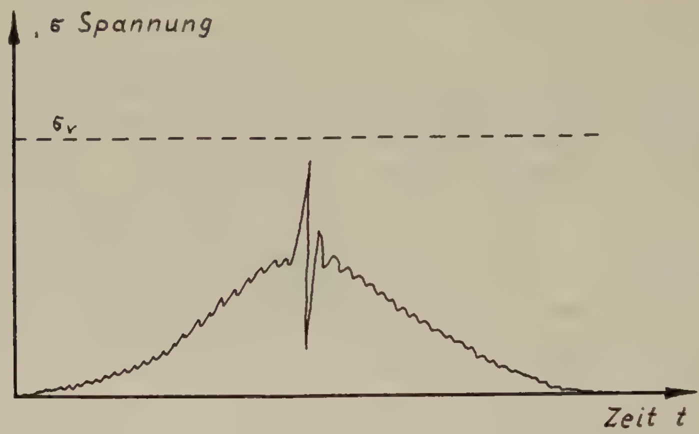
4) *Method of stressing.*

In 1950/51, the Deutsche Bundesbahn carried out by very accurate methods numerous measurements of the stresses or of the elongation at different interesting points of prestressed concrete sleepers laid on their lines, and found that even at high speeds the stressing of the concrete sleepers increases, then diminishes, in other words is essentially static in nature. Harmonics of a vibratory nature are produced, but these are insignificant as additional stresses, so that they can be neglected.

Shocks due to flats on the tyres, or badly maintained rail joints only set up sudden points of stress, which however

damp out immediately. The peak stresses occurring normally remain lower than the prestressing σ_v and are consequently harmless.

On a straight section of track, the pressure of the rail on the sleeper normally does not exceed P = 5 to 7 t. Taking P up to 30 g. As the mass participating in the vibrations is not known, it is impossible to deduct any information on the stressing of the sleeper. The only thing that can be done is to measure the elongation accurately, and this gives sufficiently clear indications.



as equal to 15 t, the increases due to shocks are fully provided.

Measurements of the acceleration of concrete sleepers under the traffic, carried out by means of very sensitive apparatus, (piezo-electric quartz accelerometers) show values which at times reach high amounts,

Experience obtained over several years confirms the observations of 1950/51. One fact in particular is of great importance, and that is that sleepers badly cracked under a single static stress do not deteriorate to any considerable extent afterwards under the effects of the traffic.

[625 .143 .2]

Simplified « three moment » solution for bending of rails,

by C. Storey,

Mathematician, British Railways, Research Department.

ABSTRACT

The three moment solution of the problem of an infinitely long rail on equally spaced sprung point supports is presented in a simplified form. After determining a number of parameters which depend on the track constants, it only remains to solve at most two pairs of simple simultaneous equations, instead of four simultaneous equations with complex coefficients as in hitherto accepted methods.

Some practical applications of the theory are given.

* * *

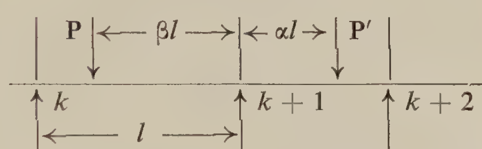
In 1921, R. Desprets (1) gave a solution for the problem of an infinite beam on equally spaced elastic point supports. His solution was based on the theorem of three moments, and he gave numerical results for the case of a load on a support and for the case of a load midway between two supports. Then, in a paper presented to the Institution of Civil Engineers in 1938 (2), Gough revived the method and gave numerical results for loads at various distances from the supports.

In this latter paper the details of the computations are not given, but the author does refer to the difficulty of handling the complex quantities which arise. By the method set out below much of the difficulty and labour Gough refers to can be avoided. As an example of the use of the method, the dependence of the maximum bending moment and deflection on the support spacing is investigated.

THEORY

A brief summary of the three moment solution of the problem, together with details of the modifications, is now given.

For a pair of spans loaded as shown



the most general form of the three moment theorem is :

$$\frac{6\,\mathrm{E\,I}}{l^2}(y_k + y_{k+2} - 2\,y_{k+1})$$

$$= -\frac{1}{2}\,wl^2 + (\mathrm{M}_k + \mathrm{M}_{k+2} + 4\,\mathrm{M}_{k+1})$$

$$- l\{\mathrm{P}\beta(1-\beta)(2-\beta) + \mathrm{P}'\alpha(1-\alpha)(2-\alpha)\} \quad . \; . \; . \; . \; . \quad (1)$$

in which E, I, have their usual meaning, l is the spacing, w is the *wt*/unit run of the beam, and y's and M's are deflections and bending moments respectively. On

neglecting the weight of the beam, and making the assumption $R_k = \rho y_k$ where R_k is the reaction at the k^{th} support and ρ the modulus of foundation, (1) reduces to :

$$\left.\begin{aligned} &\frac{6EI}{\rho l^2}(R_k + R_{k+2} - 2R_{k+1}) \\ &= (M_k + M_{k+2} + 4M_{k+1}) \\ &- l\{P\beta(1-\beta)(2-\beta) \\ &+ P'\alpha(1-\alpha)(2-\alpha)\} \end{aligned}\right\} \quad (2)$$

We can express the reactions in terms of the bending moments by considering the statics of the above two spans. Most generally we have :

$$\begin{aligned} (P + P')\,l - lR_{k+1} &= \beta lP + \alpha lP' \\ &-(2M_{k+1} - M_k - M_{k+2}) \quad . \quad (3) \end{aligned}$$

By combining equations (2) and (3) and writing

$$\gamma = \frac{6EI}{\rho l^3}$$

we have, for non-loaded spans :

$$\begin{aligned} &\gamma M_{k-1} + (1-4\gamma)M_k + (4+6\gamma)M_{k+1} \\ &+ (1-4\gamma)M_{k+2} + \gamma M_{k+3} = 0 \quad . \quad . \quad (4) \end{aligned}$$

which, on putting :

$$M_{k-1} = xM_k = x^2M_{k+1} = x^3M_{k+2} = \ldots$$

gives the following reciprocal equation for x :

$$\begin{aligned} &\gamma x^4 + (1-4\gamma)x^3 + (4+6\gamma)x^2 \\ &+ (1-4\gamma)x + \gamma = 0 \quad . \quad . \quad (5) \end{aligned}$$

For $\gamma > \dfrac{1}{24}$ the solutions of this equation are all complex and, since for all actual permanent way γ is always >1, these complex roots are of most interest. The four solutions fall into two pairs of conjugate complex quantities, and it is expedient to take that pair with real and imaginary parts <1 since the bending moments form a decreasing series on moving out from the load.

If x_1 and x_2 are two such solutions, then for the general problem shown :

$$\begin{array}{cccccc} & & \mid \alpha l \downarrow P & & & \\ \hline \uparrow k-2 & \uparrow k-1 & \uparrow k & \uparrow k+1 & \uparrow k_{+2} & \uparrow k+3 \end{array}$$

we may write :

$$\left.\begin{aligned} M_k &= p + q & M_{k+1} &= r + s \\ M_{k-1} &= x_1p + x_2q & M_{k+2} &= x_1r + x_2s \\ M_{k-2} &= x_1^2p + x_2^2q & M_{k+3} &= x_1^2r + x_2^2s \\ M_{k-3} &= x_1^3p + x_2^3q & M_{k+4} &= x_1^3r + x_2^3s \end{aligned}\right\} (6)$$

To determine p, q, r and s, the general equations (2) and (3) are used to obtain the following four equations for the spans in the neighbourhoud of the load :

$$\left.\begin{aligned} &\gamma M_{k-3} + (1-4\gamma)M_{k-2} + (4+6\gamma)M_{k-1} \\ &\quad + (1-4\gamma)M_k + \gamma M_{k+1} = Pl\gamma(1-\alpha) \\ &\gamma M_{k-2} + (1-4\gamma)M_{k-1} + (4+6\gamma)M_k \\ &\quad + (1-4\gamma)M_{k+1} + \gamma M_{k+2} \\ &\quad = Pl\alpha(1-\alpha)(2-\alpha) - Pl\gamma(2-3\alpha) \\ &\gamma M_{k-1} + (1-4\gamma)M_k + (4+6\gamma)M_{k+1} \\ &\quad + (1-4\gamma)M_{k+2} + \gamma M_{k+3} \\ &\quad = Pl\alpha(1-\alpha^2) + Pl\gamma(1-3\alpha) \\ &\gamma M_k + (1-4\gamma)M_{k+1} + (4+6\gamma)M_{k+2} \\ &\quad + (1-4\gamma)M_{k+3} + \gamma M_{k+4} = Pl\gamma\alpha \end{aligned}\right\} (7)$$

It is seen from these equations that p, q, r and s are pairs of conjugate numbers (as indeed they must be in order that the bending moments be real). Suppose then that :

$$\left.\begin{array}{ll} p = A + iB & r = C + iD \\ q = A - iB & s = C - iD \end{array}\right\} \quad (8)$$

then because x_1 and x_2 are conjugate, and using the fact that x_1 and x_2 satisfy the reciprocal equation (5), the above four equations simplify greatly to give four real valued equations with relatively simple coefficients. These reduced equations are :

$$\left.\begin{array}{l} aA - bB + \gamma C = \frac{1}{2} Pl\gamma (1 - \alpha) \\ cA - dB + eC - fD \\ = \frac{1}{2} Pl\alpha (1 - \alpha)(2 - \alpha) - \frac{1}{2} Pl\gamma (2 - 3\alpha) \\ eA - fB + cC - dD \\ = \frac{1}{2} Pl\alpha (1 - \alpha^2) + \frac{1}{2} Pl\gamma (1 - 3\alpha) \\ \gamma A + aC - bD = \frac{1}{2} Pl\gamma\alpha \end{array}\right\} \quad (9)$$

where $$-\frac{\gamma}{x_1} = a + ib$$

$$\left\{-\frac{(1 - 4\gamma)}{x_1} - \frac{\gamma}{x_1^2}\right\} = c + id$$

$$\{\gamma x_1 + (1 - 4\gamma)\} = e + if$$

In these general equations, let :

$$\begin{array}{ll} X = A + C & Y = B + D \\ V = A - C & W = B - D \end{array}$$

Then by first adding and then subtracting them in pairs 1, 4, and 2, 3, two sets of simple equations for X, Y and V, W are obtained. Because of the symmetry further simplification is possible when

$$\alpha = 0 \text{ or } \frac{1}{2}.$$

(Details of the method of computation follow).

When $\alpha \neq 0$ the bending moment under the load is given by :

$$M\alpha_l = -P\alpha(1 - \alpha)l + (1 - \alpha)M_k + \alpha M_{k+1} \quad . \quad . \ (10)$$

COMPUTING METHOD

The first step is to solve the reciprocal equation (5), i.e. :

$$\gamma x^4 + (1 - 4\gamma)x^3 + (4 + 6\gamma)x^2 + (1 - 4\gamma)x + \gamma = 0$$

where $$\gamma = \frac{6EI}{\rho l^3}$$

This is easily done by making the substitution

$$y = x + \frac{1}{x}$$

and gives us x_1 and x_2. (Graphs of the real and imaginary parts of x_1 against γ are given). Next the coefficients of the equations for p, q, r and s, are calculated from the relations :

$$-\frac{\gamma}{x_1} = a + ib$$

$$\left\{\frac{-(1 - 4\gamma)}{x_1} - \frac{\gamma}{x_1^2}\right\} = c + id$$

$$\{\gamma x_1 + (1 - 4\gamma)\} = e + if$$

$$\gamma\left(x_1 - \frac{1}{x_1}\right) = g + ih$$

$$\left\{\gamma\left(x_1^2 - \frac{1}{x_1^2}\right) + (1 - 4\gamma)\left(x_1 - \frac{1}{x_1}\right)\right\} = j + ik$$

and three separate cases are distinguished.

1. $\alpha = 0$.

2 . $\alpha = \frac{1}{2}$.

3. Other values of α (α being the distance of the load from the nearest left-hand support).

Case 1. $\alpha = 0$.

$\downarrow$ P

M_{k+2} M_{k+1} M_k M_{k+1} M_{k+2}

With notation of the diagram :

$$M_k = p + q$$
$$M_{k+1} = x_1 p + x_2 q$$
$$M_{k+2} = x_1^2 p + x_2^2 q$$
$$\ldots \ldots \text{ etc}$$

where $p = A + iB$

and $q = A - iB$

are given by :

$$gA - hB = \frac{1}{2} Pl\gamma$$
$$jA - kB = - Pl\gamma$$

Case 2. $\alpha = \frac{1}{2}$.

$\downarrow$ P

M_{k+1} M_k M_k M_{k+1} M_{k+2}

Here we have :

$$M_k = p + q$$
$$M_{k+1} = x_1 p + x_2 q$$
$$M_{k+2} = x_1^2 p + x_2^2 q$$
$$\ldots \ldots \text{ etc.}$$

where $p = A + iB$

and $q = A - iB$

(not the same A and B as above)

are given by :

$$(a + \gamma) A - bB = \frac{1}{4} Pl\gamma$$
$$(c + e) A - (d + f) B = \frac{3}{16} Pl - \frac{1}{4} Pl\gamma$$

Case 3. Other values of α.

$\alpha l \downarrow$ P

M_{k-2} M_{k-1} M_k M_{k+1} M_{k+2}

In this more general case, let :

$$M_k = p + q \qquad M_{k+1} = r + s$$
$$M_{k-1} = x_1 p + x_2 q \qquad M_{k+2} = x_1 r + x_2 s$$
$$M_{k-2} = x_1^2 p + x_2^2 q \qquad M_{k+3} = x_1^2 r + r_2^2 s$$
$$\ldots \ldots \text{ etc.} \qquad \ldots \ldots \text{ etc.}$$

where $p = A + iB$

$q = A - iB$

and $r = C + iD$

$s = C - iD$

are given by first solving the two pairs of simultaneous equations :

$$(a + \gamma) X - bY = \frac{1}{2} Pl\gamma$$
$$(c+e) X - (d+f) Y = \frac{3}{2} Pl\alpha (1 - \alpha) - \frac{1}{2} Pl\gamma$$
$$(a - \gamma) V - bW = \frac{1}{2} Pl\gamma - Pl\gamma\alpha$$

$$(c - e)\,V - (d - f)\,W = \frac{1}{2}\,Pl\alpha\,(1 - \alpha)\,(1 - 2\,\alpha) - \frac{3}{2}\,Pl\gamma\,(1 - 2\,\alpha)$$

and then applying the relations :

$$A = \frac{1}{2}(X + V) \qquad C = \frac{1}{2}(X - V)$$

$$B = \frac{1}{2}(Y + W) \qquad D = \frac{1}{2}(Y - W)$$

DEFLECTIONS

The deflections at the supports are easily calculated once the bending moments are known. We use the equation (3) above, but substitute y_{k+1}/ρ for R_{k+1}.

In the case of a pair of non-loaded spans this is simply :

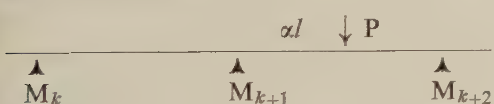
$$y_{k+1} = -\frac{1}{\rho l}\,(M_k + M_{k+2} - 2\,M_{k+1})$$

For the case :

it is :

$$y_{k+1} = \frac{1}{\rho l}\{Pl\alpha - (M_k + M_{k+2} - 2\,M_{k+1})\}$$

and for the case :



it is :

$$y_{k+1} = \frac{1}{\rho l}\{Pl\,(1 - \alpha) - (M_k + M_{k+2} - 2\,M_{k+1})\}$$

These expressions enable the deflections at the supports to be obtained in all cases.

The deflection under the load when $\alpha \neq 0$ is given by :

$$EIy_{\alpha l} = (1 - \alpha)\,EIy_k + \alpha\,EIy_{k+1} + \frac{1}{6}\,\alpha l^2\,(\alpha - 1)\,(2 - \alpha)\,M_k + \frac{1}{6}\,\alpha l^2\,(\alpha^2 - 1)\,M_{k+1} + \frac{1}{3}\,Pl^3\alpha^2\,(\alpha - 1)^2$$

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ACKNOWLEDGMENTS

The author wishes to thank Mr. T.M. HERBERT, Director of Research, British Railways Research Department, for permission to publish this article. His thanks are also due to Miss P. BURLEY and M. BALL for help with the computations.

APPENDIX.

PRACTICAL APPLICATION OF THE COMPUTATIONS

First we give a specimen calculation for $\gamma = 1$ and for $\alpha = 0$ and $\alpha = \frac{1}{2}$.

Equation (5) becomes :

$$x^4 - 3\,x^3 + 10\,x^2 - 3\,x + 1 = 0$$

Dividing through by x^2 and writing $y = x + 1/x$ gives :

$$y^2 - 3\,y + 8 = 0$$

therefore,

$$y = 1{\cdot}5 \pm 2{\cdot}397{,}916\;i$$

Since $y = x + 1/x,$

$$x^2 - xy + 1 = 0$$

and $x = y/2 \pm 1/2\,(y^2 - 4)^{1/2}$

Thus, $x = 0{\cdot}75 \pm 1{\cdot}198{,}958\,i$

$$\pm\, 0{\cdot}601{,}281 \pm 1{\cdot}495{,}506\,i$$

giving

$$x_1 = 0{\cdot}148{,}720 + 0{\cdot}296{,}548\,i$$
$$x_2 = 0{\cdot}148{,}720 - 0{\cdot}296{,}548\,i$$

We then have :

$$x_1^2 = -\,0{\cdot}065{,}764 + 0{\cdot}088{,}203\,i$$
$$x_1^3 = -\,0{\cdot}035{,}959 - 0{\cdot}006{,}402\,i$$

etc.

$$1/x_1 = 1{\cdot}351{,}283 - 2{\cdot}694{,}470\,i$$
$$1/x_1^2 = -\,5{\cdot}432{,}796 - 7{\cdot}286{,}493\,i$$
$$x_1 - 1/x_1 = -\,1{\cdot}202{,}563 + 2{\cdot}991{,}018\,i$$
$$x_1^2 - 1/x_1^2 = 5{\cdot}367{,}032 + 7{\cdot}374{,}696\,i$$

From which we obtain :

$a = -1{\cdot}351{,}283$	$f = 0{\cdot}296{,}548$
$b = 2{\cdot}694{,}470$	$g = -1{\cdot}202{,}563$
$c = 9{\cdot}486{,}645$	$h = 2{\cdot}991{,}018$
$d = -0{\cdot}796{,}917$	$j = 8{\cdot}974{,}720$
$e = -2{\cdot}851{,}280$	$k = -1{\cdot}598{,}358$

Therefore, for $\alpha = 0$

$$-1{\cdot}202{,}563\,\mathrm{A} - 2{\cdot}991{,}018\,\mathrm{B} = {\cdot}5\,\mathrm{P}l$$
$$8{\cdot}974{,}702\,\mathrm{A} + 1{\cdot}598{,}358\,\mathrm{B} = -\,\mathrm{P}l$$

giving :

$$\mathrm{A} = -0{\cdot}087{,}950\,\mathrm{P}l$$
$$\mathrm{B} = -0{\cdot}131{,}806\,\mathrm{P}l$$

from which :

$$\mathrm{M}_1 = p + q = -0{\cdot}17590\ \mathrm{P}l$$
$$\mathrm{M}_2 = x_1p + x_2q = 0{\cdot}052{,}014\mathrm{P}l$$
$$\mathrm{M}_3 = x_1^2p + x_2^2q = 0{\cdot}034{,}819\,\mathrm{P}l$$

etc.

Similarly for $\alpha = \frac{1}{2}$:

$$-0{\cdot}351{,}283\,\mathrm{A} - 2{\cdot}694{,}470\,\mathrm{B} = 0{\cdot}25\ \mathrm{P}l$$

$$6{\cdot}635{,}365\,\mathrm{A} + 0{\cdot}500{,}369\,\mathrm{B} = -0{\cdot}0625\,\mathrm{P}l$$

giving :

$$\mathrm{A} = -0{\cdot}002{,}447\,\mathrm{P}l$$
$$\mathrm{B} = -0{\cdot}092{,}464\,\mathrm{P}l$$

from which :

$$\mathrm{M}_1 = p + q = -0{\cdot}004{,}893\,\mathrm{P}l$$
$$\mathrm{M}_2 = x_1p + x_2q = 0{\cdot}054{,}112\mathrm{P}l$$
$$\mathrm{M}_3 = x_1^2p + x_2^2q = 0{\cdot}016{,}633\,\mathrm{P}l$$

etc.

In this case the bending moment under the load is obtained from equation (10) :

$$\mathrm{M}_{\frac{1}{2}l} = -\,1/4\,\mathrm{P}l + \mathrm{M}_1 = -\,0{\cdot}254{,}893\,\mathrm{P}l$$

In practical units for 95 lb/yd bull head rail (EI = 465,047) with $\rho = 94$ tons/inch, $l = 31''$, the bending moment under the load in the above two cases for a 10-ton load is :

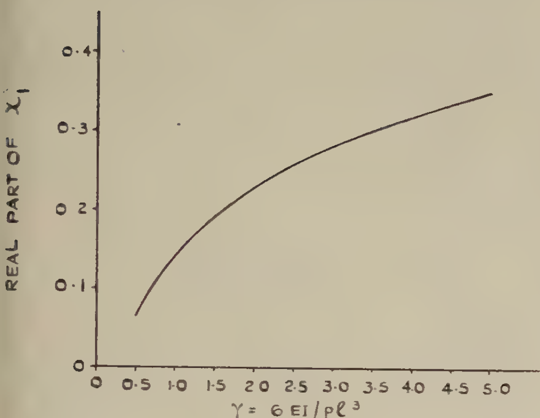
1. $\alpha = 0$ $\quad \mathrm{M}_1 = -\,54{\cdot}5$ tons inches

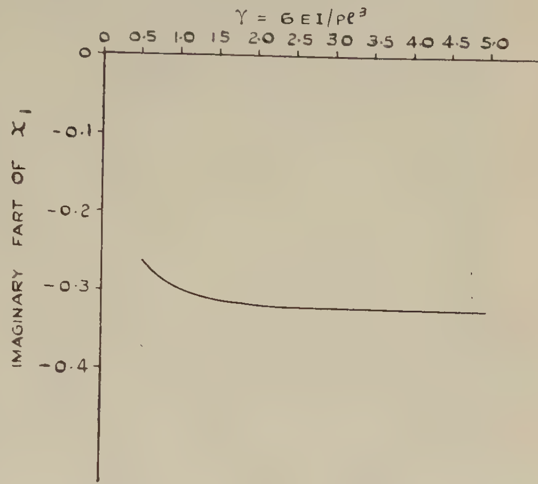
2. $\alpha = \frac{1}{2}$ $\quad \mathrm{M}_{\frac{1}{2}l} = -\,79{\cdot}0$ tons inches

Finally, in diagrams 1 - 4 the dependence of bending moment and deflection on support spacing is shown graphically as a further illustration of the use of the method. The load is taken as 10 tons, the modulus of foundation as 120 tons/inch, and EI = 465,047.

APPENDIX.

SOLUTION OF RECIPROCAL EQUATION





NEGATIVE BENDING MOMENT UNDER LOAD

I. — Load on support.

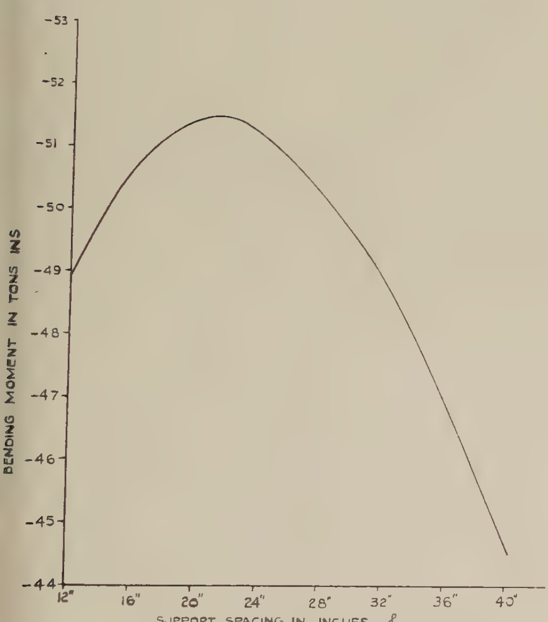


Fig. 1.

DEFLECTION UNDER LOAD

I. — Load on support.

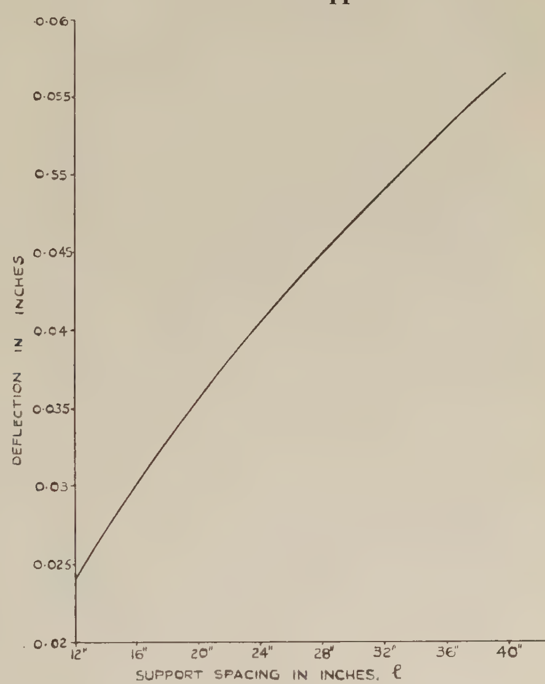


Fig. 2.

APPENDIX.

NEGATIVE BENDING MOMENT UNDER LOAD

II. — Load at midspan

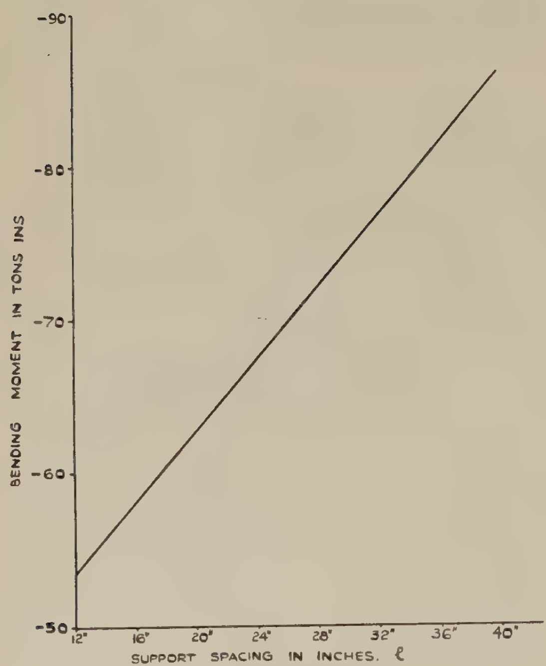


Fig. 3.

DEFLECTION UNDER LOAD

II. — Load at midspan

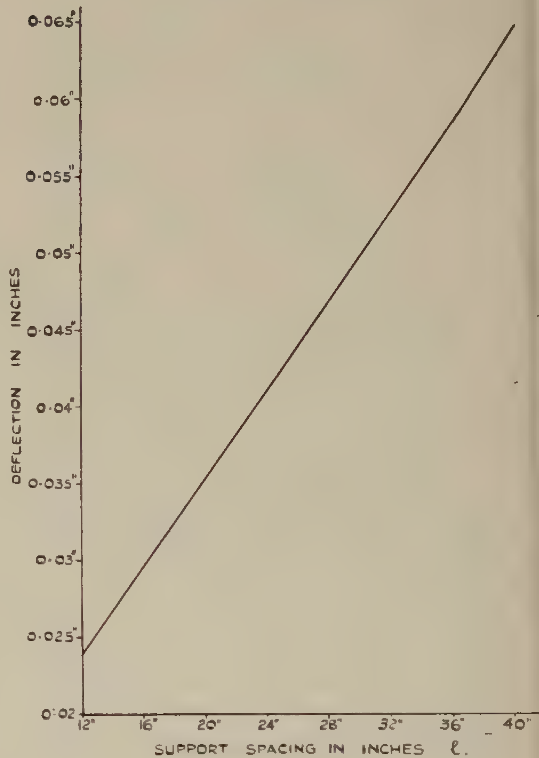


Fig. 4.

[625 .285]

The technical evolution of the fast automotor trains and the results obtained in service.

Exploiting the experience acquired to design the future trains « Trans-Europ-Express »,

by Dipl.-Ing. Otto TASCHINGER,

(Continuation and end.) (*)

(*Die Bundesbahn*, No. 6, March 1956.)

Large compartments or separate compartments.

The different fast railcars have been designed as one or other of the two types : large open compartments, or separate compartments. Which is best is controversial. The large open compartments have the advantage of reducing the weight and give a more agreeable sense of space. Many passengers prefer the large compartment to the restriction of separate compartments. On the other hand, large open compartments are not always in general favour, as it is only necessary to open one window to cause draughts. Moreover, the internal noises are louder in large compartments than in small separate ones. Modern acoustic technique, it is true, makes it possible to keep inside noise down to a reasonable limit even in large compartments. In air conditioned coaches, the passenger compartments have fixed windows. It is impossible to open the windows, which does away with any trouble due to draughts. Fixed windows also have the advantage of keeping out all dust and soot from the compartments. In the case of large compartments with air conditioning it is no longer necessary to provide separate smoking and non-smoking compartments, as the cigar or cigarette smoke is immediately carried off without any disturbance to passengers sitting nearby. There is therefore a more uniform user of the seats available.

The seats in the large compartments of the articulated motor rakes are fitted with high backs. They all face in the same direction, so none of the passengers are sitting opposite each other. With this arrangement, the passenger is less disturbed by his neighbours than in the separate compartments with their two rows of seats facing each other. The seats can be adjusted to the reclining position, so that the passenger can either read or rest, an advantage it is impossible to offer in a fullly occupied separate compartment.

The separate compartments result in a heavier vehicle than where there is one large compartment, and additional room is taken up by the corridor partition, with the sliding doors of the compartments and by the partitions separating the compartments. These therefore reduce, though only a little it is true, the width and length of the compartments; as the width is already very restricted (26.4 m) this drawback must not be underestimated. When the separate compartment is fully occupied, the journey is less comfortable than in a large compartment. As the seats face each other, the passenger is more at the mercy of his fellow passengers.

In rakes where there are not many passengers, there may be some compartments with only two or three passengers in them. It is for this reason that the coupé compartments are preferred. The coaches with

(*) See the first part in the « Bulletin » for March 1957, p. 204.

coupés have a side corridor which passengers use to stretch their legs during long runs.

Restaurant car services.

When the fast railcars were first introduced, it was considered that the passengers should be able to have a meal during their journey. The most divers technical possibilities as regards the restaurant service have been tried out on the various types of fast railcars on the Deutsche Bundesbahn. Two important considerations have influenced the type of installation to be chosen for this service : the weight and the constructional cost involved. The additional constructional costs due to the restaurant service do not have a decisive effect upon the financial results of the fast railcar services as a whole. On the other hand, the additional weight for providing special restaurant cars is considerable in relation to the weight of the rake. When the fast railcars were first introduced, the question of weight could even be the decisive one, seeing that the Diesel engines then available only had a limited power. But thanks to the modern technique of light weight construction, the weight of the vehicles has been successfully reduced without endangering safety to such an extent that in the most recent fast railcars with special restaurant car compartments, the weight per seat is lower than in the old types of rake without separate dining saloons. For example, the « Flying Hamburger » on which there is no restaurant car weighs 87 t for 77 seats, so that the weight per seat is 1 120 kg (2 469 lbs.), whereas in the series 08 triple rake weighing 119 t, there are 114 seats, without counting the seats in the restaurant car. The weight per seat is therefore only 1 044 kg (2 301 lbs.).

The restaurant car service may be provided by :

1) a buffet. The buffet service, which enables cold meals to be served with to a limited extent some hot dishes, is only suitable for short runs;

2) on the other services, normal meals must be served, the preparation of which entails a kitchen and pantry. The meals can be served :

a) to the passengers in their compartments on small folding tables, or small loose tables hooked into holders, or

b) in a special restaurant-saloon.

Serving meals to passengers in their compartments has certain drawbacks. If the folding table under the window is not large enough to serve the meal, the waiter has to fetch and put up other folding tables, for which special storage place has to be provided. The tables are rather narrow, unless the seats are spaced wider apart for the purpose. Moreover, it is tiresome for passengers who do not wish to have a meal to be seated at the same table as others who are eating. In rakes of a certain length, the kitchen is often some way off, which slows down the service and prolongs the time taken for meals. The separate restaurant saloon on the other hand has a great many advantages. The arrangement of the car may be very similar to a hotel dining room. It immediately adjoins the kitchen and pantry, which ensures that meals are served hot. Only those who wish to have a meal go to the restaurant car. And going to the restaurant car generally makes a welcome change for the passengers.

Running noises inside the coach.

In railway vehicles with engines, the outside noise may under bad conditions be as much as 120 phons or even more. The inside noises do not have the same intensity in the different coaches of the fast railcars. To the running noises are added in the motor units, the noise of the mechanical installation, whereas in the trailers there is only the noise of running like on ordinary train coaches. When the motor installations are mounted on the bogies, the noise they set up can be damped out for the passengers by putting immediately behind the engine room compartments which are not used by the passengers, for example, the luggage compartment, the mail

compartment, the entry vestibule, the kitchen and pantry, etc.

Putting these compartments in front of the passenger compartments is usually sufficient to assure adequate protection against the noise of the machinery. The passenger compartments of modern railcars no longer suffer from running noises. The bodies of the coaches of the fast railcars built before the war have not yet been fitted with special sound insulation. This was first used on the series 08 long distance multiple units, where the interior noises had already been considerably reduced. The reduction in noise was obtained by efficient insulation, absorption and sound proofing of the thin sheeting used for the coach bodies. The successful results are also due to the insulated intercommunication doors which close automatically, fitted in the ends of the coaches, which reduced the noise in the vestibules by 6 phons. The increased weight due to these measures is, it is true, considerable. It amounts to 8 to 10 % of the weight of a non-insulated coach. The cost is increased in the same proportion.

A more difficult and more costly problem was the effective sound insulation of the articulated motor rakes. The articulated units, the length of each of which is only about 12 m, are much shorter than the series 08 coaches (26 m). At the ends of the articulated units, the end walls have been fitted with large windows intended to give an impression of spaciousness, so they cannot be shut in by doors. Moreover, the restaurant service (there is no dining-saloon in the articulated daytime rake) makes it impossible to fit intercommunication doors. The axles, where a lot of noise originates, are immediately below the end walls of the different coaches. The windows are therefore in the place where the intensity of the outside noise is at its highest. On the outside, the intercommunication passages have been covered in with a rubber bellows, doubled on the inside by a second protective rubber coating. Both of these as we know have a very low coefficient of insulation. The fitting of insulating materials in the intercommunication equipment is difficult, costly, and leads to a considerable increase in the weight. The remaining surfaces of the end walls, apart from the windows, must also be strongly insulated and made to take as much part as possible in absorbing noise. In the same way, all available surfaces of the side walls and the ceiling must be used to absorb noise. But unless there are insulated intercommunication doors, the results obtained are limited. In spite of all the measures taken, it has not been possible to reduce to any great extent the noise set up by the wheels. Now this noise has a considerable influence upon the passenger's estimate of the running qualities.

Heating and ventilating installations. (Air conditioning plant.)

In the motor units of the fast rakes use has always been made of the heat contained in the engine cooling water to heat the unit. Usually, in addition, a hot water boiler equipped with a gas-oil burner is added to the cooling water circuit, which is only used when the Diesel engine is not running or when it is working at reduced power. The other coaches of the rake usually have a hot water heating installation with completely automatic gas-oil boilers. Hot water heating installations have the advantage of a low superficial temperature, but it is difficult to regulate them because this takes so long. To eliminate the risk of freezing up, coaches with a hot water heating installation have to be designed in such a way that antifreezing products can be used. The drawbacks of these installations has been avoided in the case of the triple units built in 1935 (Leipzig type) on which a hot air heating installation of the Pintsch system was tried out for the first time, the heat being obtained from a burner heated by an automatically regulated burner. During the summer, the hot air heating installation is used for ventilation. A commutator makes it possible to insulate the burner and drive air from the exterior directly into the coaches. The two articulated motor rakes were fitted with the first air conditioning installations

which send hot air into the passenger compartments during the period the heating is on and cold air during the summer. These installations keep the passenger constantly supplied with fresh air. Automatic air conditioning plants have been perfected so much since then, amongst other things from the sound-proofing angle, that it is hardly possible to equip new railcars without them.

The motor installations.

The most important characteristics of the motor installations of the fast railcars have been grouped synoptically in Table 7. This table shows amongst other things the power of the engines installed in a rake. The motor installations also differ as regards the auxiliary machines driven by the principal Diesel engine and by the type of transmission. The table also shows the effective power available in each case for the traction of the rake.

Diesel engines.

Dieselisation of the passenger services has had a decisive influence on the development of fast, high powered Diesel engines. The « Flying Hamburger » which consisted of two coaches was originally equipped with a fast Diesel engine developing 400 HP at 1 400 r.p.m. The development of the fast railcar services however soon made it necessary to use rakes of three coaches, which involved increasing the power of the Diesel engine to 600 HP, the increased power being obtained by supercharging. The mechanism of this 600 HP Diesel engine was originally mounted on ordinary roller bearings which led to breakdowns after a relatively short time in service. Since their alteration by the introduction of so called tunnel bearings and the adoption of lubricating oils with additives, these Maybach engines have given excellent results. Mileages of more than 500 000 km (310 000 miles) without repairs between two overhauls are usual. The engine cylinders only wear some 0.025 mm per 100 000 km (62 000 miles) run. It can be expected that the mileage between overhauls can be increased to well over 500 000 km. As a result the safe running of the Diesel engines has not only been increased to an exceptionally favourable level, but the cost of maintenance and stocks of spares have also been appreciably reduced.

After the war, Daimler, M. A. N. and Maybach built fast Diesel engines with a power of 800 to 1 000 HP. Such progress has made it possible to use a *single motor installation* for a three unit rake. These engines can still be housed on the bogies. The dimensions of the connections of the various engines have been standardised, so that types built by the different firms are interchangeable. These engines are also used on the Diesel locomotives of the Deutsche Bundesbahn, which is of considerable advantage from the point of view of stores and maintenance.

Two of the four unit Diesel rakes have been equipped with a slow M. A. N. Diesel engine of 1 350 HP at 700 r.p.m. The large dimensions of this engine have made it necessary to install it in the body of the coach. In this way, it has been possible to make interesting comparisons from the point of view of the construction and the working with rakes fitted with Diesel engines mounted on the bogies.

The types of Diesel engines with which we have just dealt have been specially designed for railway vehicles. The relatively small number of Diesel engines ordered at one and the same time has an effect upon the cost price. In order to reduce these costs, on the two articulated rakes mass-produced lorry-type engines developing 160 HP have been used. The power of these engines can be increased to 210 HP by supercharging. The relatively low power of these engines makes it necessary to install four engines per articulated rake, two per leading unit.

Influence of the number of motor installations.

According to the type of fast railcar, the motor installation consists of one, two

TABLE 7. — **Essential characteristics of the motor equipment of the fast railcars.**

	Type of railcar	Number of Diesel engines in the rake	Chief characteristics of the Diesel engine		Driven by the principal Diesel group						Diesel power available for traction	Auxiliary Diesel engines			Transmission gear			
			Power	Speed of rotation	Lighting and starting dynamo	Electric generator axle driven for lighting	Auxiliary generator	Fan generator	Compressor	Total power		Number	Power	Speed	hydraulic	electrical	Electric power of the generators	Electric power of the traction motors
			H.P.	r.p.m.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.		H.P.	r.p.m.			H.P.	H.P.
1	SVT 04.1 double « Flying Hamburger »	2	each 410	1400	—	—	3	16	2	42	778	—	—	—	—	yes	2 × 400	2 × 340
1*a*	SVT 04.1 double Hamburg type	2	each 410	1400	—	—	15	16	—	62	758	—	—	—	—	yes	2 × 370	2 × 340
2	Triple SVT Leipzig type Diesel-electric	2	each 600	1400	—	—	25	18	—	86	1114	—	—	—	—	yes	2 × 545	2 × 245
2*a*	The same Diesel-hydraulic	2	each 600	1400	9	—	—	18	—	54	1146	—	—	—	yes	—	—	—
3	Triple SVT Cologne type Diesel-electric	2	each 600	1400	—	—	25	20	—	90	1110	—	—	—	—	yes	2 × 545	4 × 245
3*a*	The same Diesel-hydraulic	2	each 600	1400	17	—	—	20	—	74	1126	—	—	—	yes	—	—	—

TABLE 7. — **Essential characteristics of the motor equipment of the fast railcars.** *(continued)*

	Type of railcar	Number of Diesel engines in the rake	Chief characteristics of the Diesel engine		Driven by the principal Diesel group						Diesel power available for traction	Auxiliary Diesel engines			Transmission gear			
			Power	Speed of rotation	Lighting and starting dynamo	Electric generator axle driven for lighting	Auxiliary generator	Fan generator	Compressor	Total power		Number	Power	Speed	hydraulic	electrical	Electric power of the generators	Electric power of the traction motors
			H.P.	r.p.m.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.		H.P.	r.p.m.			H.P.	H.P.
4	Four unit SVT Berlin type	1	1300	700	—	—	—	—	—	—	1300	1	120	1200	—	yes	1300	4 × 285
5	Triple VT 08.5 long distance	1	1000	1500	17	2 × 8	—	47	—	80	920	—	—	—	yes	—	—	—
6	The same four units	2	each 1000	1500	2 × 17	2 × 8	—	2 × 47	—	144	1856	—	—	—	yes	—	—	—
7	The same 5 units	2	each 1000	1500	2 × 17	3 × 8	—	2 × 47	—	152	1848	—	—	—	yes	—	—	—
8	Articulated day service rake of 7 coaches VT 10 501	4	each 210	2000	4 × 0.5	—	—	—	—	2	838	2	125	1500	yes	—	—	—
9	Articulated sleeping-car rake of 8 coaches VT 10 551	4	each 210	2000	4 × 0.5	—	—	—	—	2	838	2	125	1500	yes	—	—	—

or several engines. The railcar with *one* motor installation must be considered as the most favourable solution from the point of view of cost of construction, weight and maintenance. This presupposes however that these motor installations are capable of functioning for a long mileage, in other words that there will be no breakdowns, even slight ones, in the motor installation, unless these can be repaired during the servicing of the rake without leading to any great delays. With a *single* motor installation the consequences of any breakdown in service are naturally graver than if the railcar had two groups of engines. When one breaks down in this case the full power of the second can still be used, so that the rake will arrive at its destination without undue delay. But as the number of installations increases, the control equipment becomes more complicated. The increased number of measuring and indicating equipment, of operating and control lines which must pass from one coach to another through special couplings means an increase in the possible sources of breakdowns, and increases the cost. The cost and weight per vehicle therefore increase with the number of motor installations; maintenance becomes more complicated and supervision more difficult.

The four unit 1 350 HP Berlin type railcar consists of a motor unit and three trailers. As the transmission adopted for this rake is the electrical one, the motive power has been divided up over the whole length of the rake. One of the motor bogies is under the motor unit, a second under the driving unit beside the driver's cab. A motor unit has a certain number of appreciable advantages. Unlike a locomotive coupled to a train, this coach is connected to the rake by a streamlined device and is accessible from the rake through the intercommunication arrangements. The coaches coupled up to it do not include any mechanical equipment. In the case of the two four unit rakes, it is only necessary to have a single spare motor unit. As a result the capital cost is appreciably lower, whilst the possibilities of using the two rakes are greater.

Installation of the engines on the bogies or in the body.

As we have already remarked, it is possible to house a Diesel engine of up to 1 000 HP with its transmission on a bogie. With this arrangement, the Diesel engine projects into the body, whilst the transmission or the generator can be housed under the floor, so that the only space needed for the Diesel is in the front end of the coach body in front of the pivot where the driving compartment is. The space required for the Diesel engine and its transmission, as well as their weight, have a considerable influence upon the design of the bogie. In the case of engines of more than 600 HP the design of bogie becomes very complex and the purchase price is considerably increased. On the bogie the Diesel engine is only suspended upon the axle box springs and as a result is subjected to very great shocks. A Diesel engine mounted on a bogie together with its transmission is a well tested type of construction, making it possible to change the engine very quickly in case of accident, and consequently ensuring that the motor unit will only be out of service a very short time. The vibrations of the Diesel engine are for the most part not transmitted to the body. As the body does not have to support the heavy motor installations, it can be made light in weight. It is true that the motor bogies are definitely much heavier. Although the mechanical installation does not take up any amount of space in the body, it is hard to get at during running. In addition, the mechanical installation is subject to atmospheric influences (ice and snow) as well as to dirt. It is not possible to deaden the noise of the motor properly. The connecting up of the fuel and water pipes must be made with flexible pipes which are subjected to additional stresses by the movement of the bogie relatively to the body. The useful life of these pipes is limited, and they sometimes cause breakdowns.

On the other hand, in the coach body is is possible to install an engine of any

power in practice. The motor installation is always convenient to get at in service and it is perfectly protected against atmospheric influences. The motor installation can be kept scrupulously clean, which reduces the risk of fire. The noise of the engine and the transmission can be effectively deadened. The motor installation is also cushioned by the greater flexibility of the suspension of the body; as its mass is suspended perpendicularly on the swing bolster, the stresses applied to the axle boxes and the pressure of the flanges are reduced. On the other hand, relative movements between the engine and the motor axle must be compensated by a rather less favourable transmission from the kinematic point of view. The construction of the bogie is greatly simplified, and its cost is therefore lower. This method of construction takes up rather more space in the coach body.

Transmissions.

The first railcars of the former Deutsche Reichsbahn had electrical transmission. In the Leipzig and Cologne type railcars, electrical and hydraulic transmissions were fitted. The fast railcars built since the war in principle are only fitted with hydraulic transmissions.

The advantages and drawbacks of the two types of transmission could be clearly seen on the three unit long distance railcars, Leipzig and Cologne types, in continuous service over many years. The observations made can be summed up as follows: the safety of working of the two systems is equal. The mileages covered without anything going wrong are approximately the same. The weight in service of the Leipzig type triple railcar with electric transmission, built in 1936, is greater than that of the same railcar with hydraulic transmission by about 10.5 t i.e. 8 % of the weight in service of the railcar. It is true that at a running speed of 160 km (100 miles)/h, the influence of the resistance to movement due to the weight of the vehicle is definitely less than the air resistance. But at 60 km (37 miles)/h, this still represents 70 % of the total resistance and at 100 km (62 miles)/h, 50 %. The weight of the vehicle, however, has a decisive influence upon the acceleration on starting and the speed up gradients. When it is considered on the other hand that the mileage covered by a railcar generally includes a number of sections which must be run through at reduced speed and that an appreciable part of the line is on curves or gradients which also mean a reduction in the running speed, one is led to the conclusion that even in the case of fast railcars, the weight of the vehicles has a considerable influence. Since the second world war, the Deutsche Bundesbahn has put into service only railcars with hydraulic transmission. It is possible that in modern installations the extra

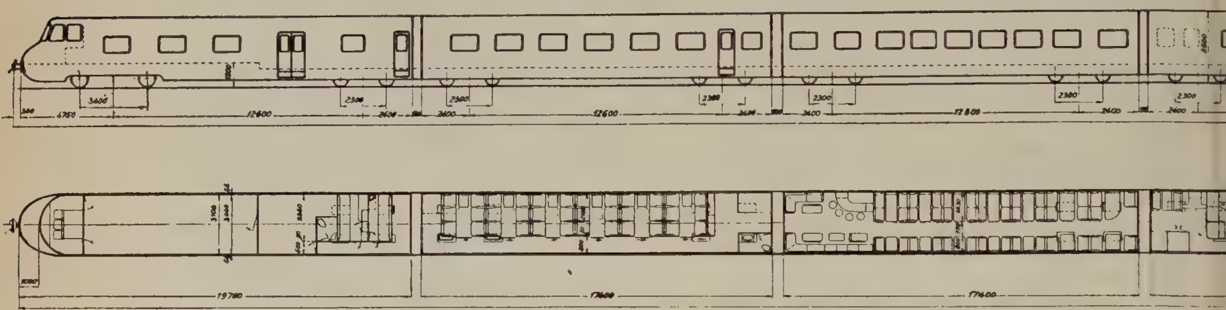


Fig. 7. — Seven

weight due to electric transmission will be appreciably reduced.

On starting and up gradients, the hydraulic transmission has a better efficiency than the electric transmission.

Electric control.

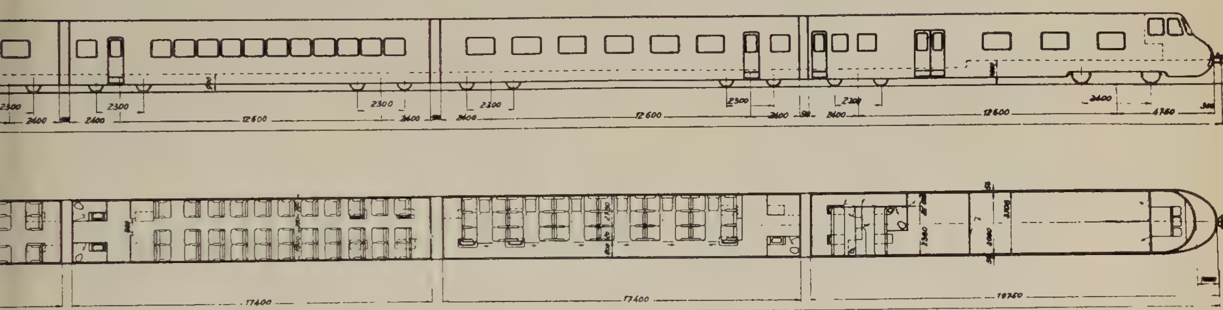
The control equipment of the train controls the level and temperature of the cooling water, the pressure of the lubricating oil and its temperature, the operations of engaging and disengaging the gears, the maximum speed of rotation of the engines and the running notches. It is also possible to control from the driving compartment: the lighting and heating installations or air conditioning of the different coaches, the compressed air brake and the air compressors, the electro-magnetic brake acting on the rail and the sanding equipment of the different vehicles. Contactors and relays of types in general use, which can be mass-produced by the makers, are used almost exclusively, so that the cost price remains within acceptable limits. The electric control is independent of the number of intermediate coaches and consequently the length of the rake. It is also independent of the possible position of the coaches in the rake. For example, six triple units coupled together can be controlled. The electric control has behaved perfectly satisfactorily in service.

Trans-Europ-Express railcars (TEE Railcars).

For some years, the series 08 fast railcars have been running the fast European Diesel service on the Dortmund-Paris, Dortmund-Ostende, Hamburg-Zurich and Hamburg-Copenhagen lines. The articulated sleeping-car rake runs between Hamburg and Zurich.

When the 1957 summer services come in, an express trans-European service (TEE for short) will be organised. The Benelux countries, France, Germany, Switzerland and Italy are sharing in the construction and running of these trains. The programme of TEE rakes to be built by the Deutsche Bundesbahn is based on experience acquired over many years with various types of fast railcars as regards construction, working and running. In the above chapters we have reported this experience; in effect, the experience acquired as regards construction has made it possible to decide without difficulty which designs amongst the different types of railcars have made the grade and can be used as a model for the TEE trains to be built.

In view of the fact that the lines on which the TEE are to be run are not all electrified as yet, as well as the fact that on the electrified lines there are different types of current, different voltages of the contact lines and different frequencies, the TEE trains can only be Diesel rakes at the moment. It must not be forgotten,



-Express » railcar.

however, in designing these rakes that in the not too far future the lines used by the TEE services will be electrified.

The question of deciding if the TEE trains should consist of rakes hauled by a locomotive or of railcar units has been the subject of a thorough-going study. In the first case, the locomotives would have to be changed at the frontier stations or at the beginning of the electrified sections. The short stop to change engines would not have any effect upon the journey time, seeing that in any case a stop of about the same length would be needed at these stations for service purposes. But trains hauled by a locomotive have a whole series of drawbacks, especially at high running speeds, which can be avoided with railcars. The front of the locomotive, in particular the steam locomotive, cannot be given as satisfactory a streamlined shape as a railcar. In the same way the ends of passenger train coaches are not streamlined; it is true that it is possible to enclose by suitable bellows the space between coupled vehicles in order to reduce the air resistance. If the ends of the locomotives are streamlined, the gap between the locomotive and the next coach is particularly large and in practice it is not possible to fill this in by streamlined bellows. The tail end of the train on the other hand when the last coach has the ordinary type of end wall, does not comply with streamlining requirements, whilst it is precisely there that streamlining is essential owing to the importance of the depression in this area. Trains hauled by locomotives therefore have a much higher air resistance coefficient that multiple railcars, which in the case of a running speed of 140 km (87 miles)/h makes it necessary to provide additional motive power and leads to much higher traction costs.

If, as is often the case, the route includes dead-end stations in the case of trains hauled by a locomotive, it is necessary to change locomotive, which may have an effect upon the economic output of the locomotive (reduced availability). The high running speed of the TEE trains (140 km/h) makes the use of reversible rakes with locomotives impracticable. To avoid accidents to passengers in case of collision, the coach to be pushed must have a very high resistance to shock in order to reduce sufficiently the influence of the locomotive pushing them. Such coaches then become heavier and lead to additional traction costs. The motor units at the two ends of the TEE trains assure great safety for the passengers. The composition of the rake adopted makes it possible to profit to the full by all the advantages of the light weight construction. If a comparison is made between a four coach long distance train, consisting of a kitchen-dining-car coach, and three passenger coaches each 26 m long hauled by a 2 000 HP Diesel locomotive and a series 08 four unit railcar consisting of two motor units each of 1 000 HP and two intermediate coaches (each of which is also 26 m long), we see that the saving in weight is 25 % in favour of the railcar. In the case of a train hauled by a steam locomotive, the difference in weight would be still greater. The much lower weight of the railcar is an advantage that cannot be overlooked.

With a train hauled by a locomotive it is possible to add or remove coaches en route. The number of coaches is only a function of the power of the locomotive. The same results can however be obtained with the railcar by using bogie coaches and making the engines sufficiently powerful. In the case of the TEE trains, a power of 2 000 HP has been allowed for, which corresponds to the power of the 2 000 HP Diesel locomotive.

To end, it should also be noted that with a railcar it is possible to go from the intermediate coaches to the motor unit, whereas on rakes hauled by a locomotive this is not possible.

The TEE rakes will have the same motor equipment as the series 08 and 12 fast multiple unit railcars and the series V 80 and V 200 Diesel locomotives, i.e. two 1 000 HP Diesel engines. The same hydraulic transmissions will also be used. This motor equipment has reached a remarkable state of perfection nowadays.

During 1955, they completed mileages of approximately 145 500 km without anything going wrong; in other words, no technical breakdowns involving taking the rake out of service or outside assistance occurred before they had completed this mileage. The use of this motor equipment on the it is remembered that these statistics cover both old and recent types, it can be concluded that the real economic results, related to the new types, are still better than the average values given. It is reasonable to think that in the case of all the most recent installations, the mileage between

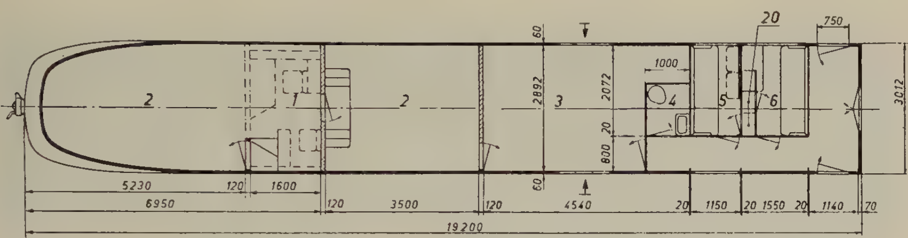


Fig. 8*a*. — Motor unit (*a*).

1. Driving compartment.
2. Engine room.
3. Luggage compartment.
4. Staff W. C.
5. Compartment for guard and German Sleeping and Dining car Company's agent.
6. Compartment for technical staff.
20. Clothes locker.

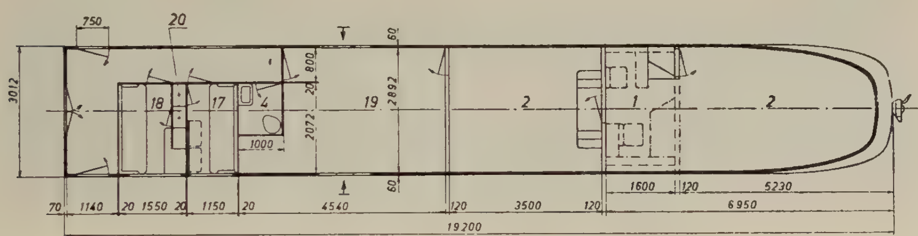


Fig. 8*b*. — Motor unit (*b*).

1. Driving compartment.
2. Engine room.
4. Staff W. C.
17. Compartment for stewardess and kitchen staff.
18. Compartment for customs and police officials.
19. Compartment for hand luggage.
20. Clothes locker.

TEE trains is therefore a guarantee of a high degree of safety of operation and confidence in its reliability, which is of particular value in the case of international traffic. The use of the same components for both the railcars and Diesel locomotives assures on the one hand extremely important economies in stocking spare parts, and on the other hand the minimum maintenance and service costs. Statistics relating to these installations show the favourable financial results obtained. When two overhauls will be between 500 000 and 1 000 000 km (310 000 and 620 000 miles).

As regards the rolling stock used on the TEE trains, the articulated rakes have been used as a pattern for the dimensions as regards the height and width of the body, the construction of the body in light metals, the comfort, the air conditioning equipment and the main outlines of the bogies. However, instead of « Jakob » bogies or two wheeled trucks as used on the articulated rakes, the TEE trains will

have separate coaches on two bogies, so that, as in the case of the ordinary passenger trains, each coach can be attached or uncoupled in stations. In the case of the carrying bogies, the Wegmann type will be used, which has been tried out on the sleeping-car rake. The lower stabilising arrangement has been borrowed from the series 08 and 12 multiple railcars. In addition the TEE coaches will be soundproofed according to the experience obtained with the VT 08 railcar. Profiting by all the experience gained in the vehicle part guarantees a high degree of comfort, and in particular proper stability of running and effective insulation of the passenger compartments against outside noise.

The TEE rake consists of bogie coaches of the same height (3 705 mm), same width (3 012 mm) and same bogie pivot spacing (12.6 m). Likewise the overhang at the coupled ends will be identical (2.4 m). At the two ends of the TEE rake, there is a motor unit (also known as the leading unit), in the middle a kitchen car and a dining-car. Between the motor unit and the kitchen car on the one hand and the end motor unit and the dining-car on the other, are the passenger coaches (fig. 7).

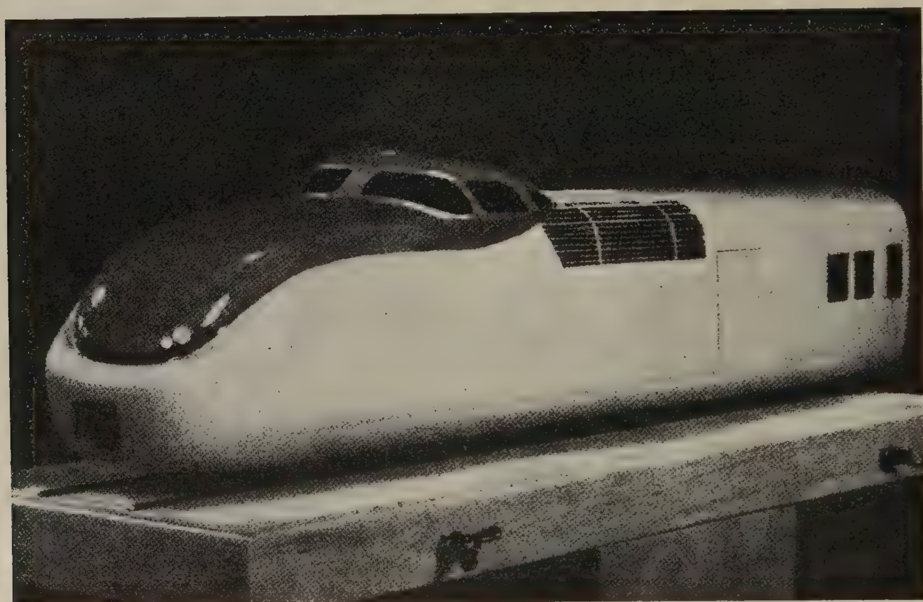


Fig. 9. — Model of the front end of leading unit.

As a general rule, a TEE railcar consists of 7 units: the two leading units (motor units), the kitchen-car, the dining-car and three ordinary coaches. The power installed is twice 1 000 HP. This makes it possible to haul three additional passenger coaches without lowering the maximum speed laid down too much or the acceleration on starting. The leading units are fitted at the end with couplings with centre buffer of the Scharfenberg completely automatic type, the coupling height of which above rail level corresponds with the regulations of the « Unité Technique » (Common Technical Standards), so that if necessary the trains can be hauled by a

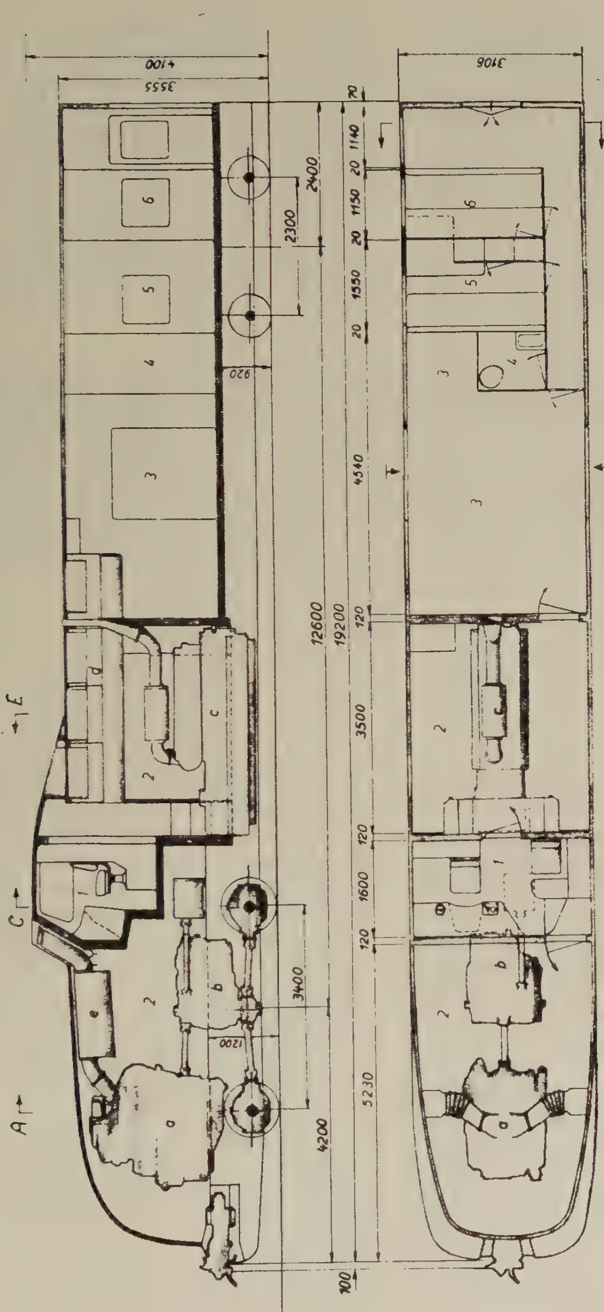


Fig. 10. — Motor installation.

1. Driving compartment.
2. Engine room.
a. Motor.
b. Transmission.
c. Auxiliary group.
d. Cooling equipment.
e. Sound deadened exhaust pot.
3. Luggage compartment.
4. Toilet.
5. Compartment for customs or technical staff.
6. Compartment for guard or stewardess.

locomotive. The rigid couplings between the different units are also couplings with a centre buffer, arranged on the frame in such a way that the passage from one vehicle to another is always on the same level. The stabilising arrangements are articulated behind the couplings in such a way that the coaches can be uncoupled in service without difficulty. The gaps between the coaches are covered in completely by means of a rubber bellows. The rakes have disc brake equipment.

customs and police, and an entrance vestibule. The 1 000 HP Diesel engine is fitted on the frame, in the engine room above the first bogie axle on a vibration damping subframe.

The engine powers of the two end units are calculated in such a way that the TEE train can run at a maximum speed of 140 km (87 miles) and attain 70 km (43 miles)/h up a gradient of 16 °/₀₀. The exhaust gases from the engine are evacuated upwards between the two windows

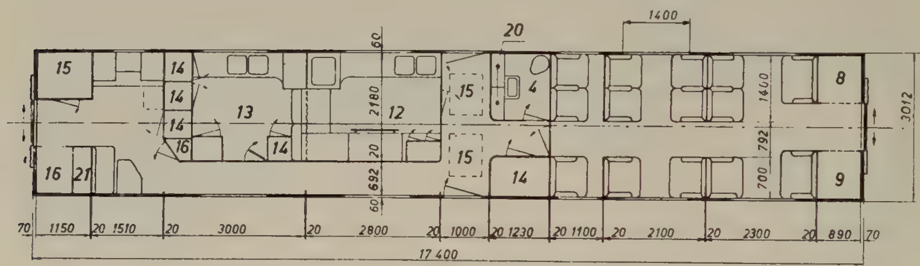


Fig. 11. — Kitchen-car.

4. Staff W. C.
8. Cloak-room.
9. Cases locker.
12. Kitchen.
13. Pantry.
14. Refrigerator cupboard.
15. Stores.
16. Toilet.
20. Clothes locker.
21. Apparatus locker.

The two leading units (fig. 8*a* and 8*b*) are completely identical and consequently interchangeable. They have no passenger compartments. The motor unit is 19.2 m long. On the driving compartment side the overhang is 4.2 m. The motor bogie has a wheelbase of 3.4 m. In the engine compartment, the height of the floor above rail level is 1 350 mm. In the service and luggage compartments, the floor is 1 070 mm above rail level. In one of the leading units (*a*), in addition to the engine room and driving compartment, there is a luggage compartment for large luggage, a W. C. for the use of the staff, a compartment for the guard and the driver, a compartment for the technical staff, and an entrance for passengers; in the other unit (unit *b*), in addition to the engine room and driving compartment, there is a W. C. for the use of the staff, a compartment for the stewardess, a compartment for the

of the driving compartment through a soundproofed exhaust pot. The hydraulic transmission is arranged in the body, above the centre of the bogie; the lower part of its output shaft penetrates through the motor bogie and transmits the motor torque to the two axles through two cardan shafts. The raised up driving compartment is sited more or less above the rear axle. In front of the driver's seat, there is a sufficient long deformable bonnet, which is very effective in protecting the staff against the effects of collisions. This space is separated from the engine room by sound-insulated partitions. Towards the front, there is a swing door making it possible to pass from the driving compartment to the engine room where is the Diesel engine and the transmission, and towards the rear another door gives access to a space in which there is the auxiliary Diesel group and the cooling

equipment. The auxiliary Diesel group consists of a 220 HP Diesel engine revolving at 3 000 r.p.m. and a three phase 380/220 V generator supplying the current for the auxiliary equipment, i.e. the starter, the controls, the compressor, the air conditioning equipment, the heating, the kitchen (cooker, refrigerators, etc.) the electro-magnetic rail brakes, the « Indusi » system, etc. The power of the auxiliary Diesel group has been so calculated that even with the longest trains, there is sufficient current to meet all requirements. The engine cooling system fitted with hydrostatically driven fans, is above the auxiliary Diesel group. This makes it unnecessary to have the usual battery which takes up a lot of space, is heavy, and requires much maintenance. The luggage compartment and the compartments used by the staff are heated by the heat generated by the engine.

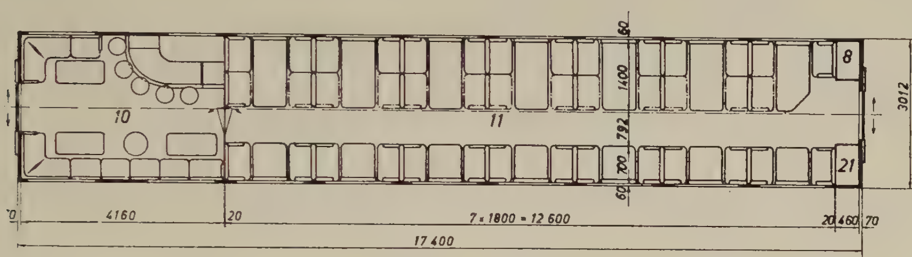


Fig. 12. — Restaurant-bar car.

8. Cloak-room.
10. Bar.
11. Dining-room.
21. Apparatus locker.

The fitting of the motor installation in the two units at the two ends of the train has great technical and economic advantages.

We have already explained the advantages of the distribution of the total engine power between two motor units from the point of view of improved availability. The power chosen for a leading unit is sufficient to haul the railcar at the maximum speed, even up slight gradients. It is only on starting and up steep gradients that the power of the second unit is needed. The second unit thus acts as a standby locomotive. Actually in long distance express services, stops (starting up points) are few. The sections on steep gradients in general do not amount to more than 5 to 15 % of the total run. For the greater part of a TEE run, only the full power of the one leading unit is necessary. It follows from these considerations that it is sufficient when coming to an electrified section, to substitute for one Diesel end unit, an electric unit. The second Diesel unit remains coupled up to the train. The fact that only one unit has to be changed simplifies coupling and uncoupling in the terminal stations considerably; shunting is unnecessary and the stops need not be so long. As the end units do not carry any passengers, when the motor unit is changed, no passengers have to change coaches. The TEE railcar in this connection has all the advantages of a rake hauled by a locomotive. When having to change a single motor unit, it is an advantage for the Diesel and electric installations to be operated by the same controller. In this case, the thermal engine and the electric engine must have the same speed of rotation and the same torque. In the TEE rakes, this condition is realised because the motor power of the electric traction motor which is also installed in the body of the coach is transmitted to the driving wheels by the same hydraulic transmission with cardan shafts as in the motor units with thermal engine. By keep-

ing one of the Diesel motor units attached to the rake, safety of operation is increased on the electrified lines, seeing that should there be any failure in the power supply, the Diesel unit can take the rake beyond the cut-out section without any appreciable delay. Another advantage of changing only one unit lies in the fact that the number of electric motor units to be acquired is thus halved.

The kitchen-car is shown in plan in figure 11. Kitchen and pantry are sufficiently large in size and the number and size of the ordinary and refrigerator cupboards have been so designed that it is no longer necessary to store any provisions in the corridors and vestibule. Special attention had also to be paid to the considerable length of the journey. The coach includes a kitchen 2.8 by 2.18 m and a pantry 3 m long.

In the kitchen there is an electric cooker with six hot plates taking about 16 kW. There is a table all along the outside wall for the preparation of the dishes. In the pantry, there is a drain-off sink and five electric refrigerator cupboards (14). The dishes are passed through a hatch in the partition of the widened corridor. In the vestibule giving access to the dining-car is a store cupboard (15) a linen cupboard (16) as well as the racks for the plates and cutlery. There is a seat and desk for the head waiter and a cupboard for used linen (16). Another refrigerator cupboard (14) and a toilet (4) are provided in the entry vestibule. In addition, special lockers for provisions are also provided in the false floor; these are reached through lateral trapdoors during stops at stations and by trapdoors in the floor of the vestibule (15).

In carrying out the interior arrangements care has been taken to avoid using any materials likely to rot. For the sinks, etc., rustless steel has been used. The kitchen,

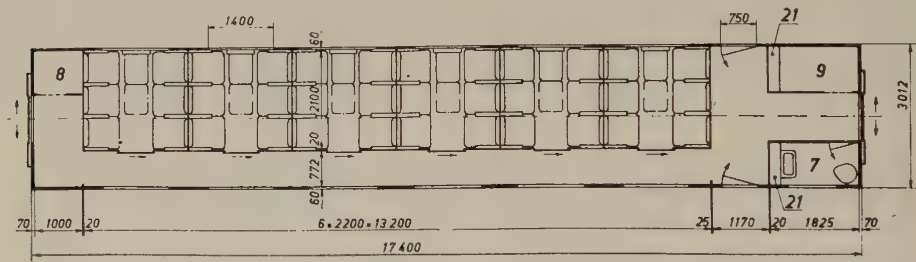


Fig. 13. — Passenger coach.

7. W. C.-toilet.
8. Cloak-room.
9. Hand luggage racks.
21. Apparatus locker.

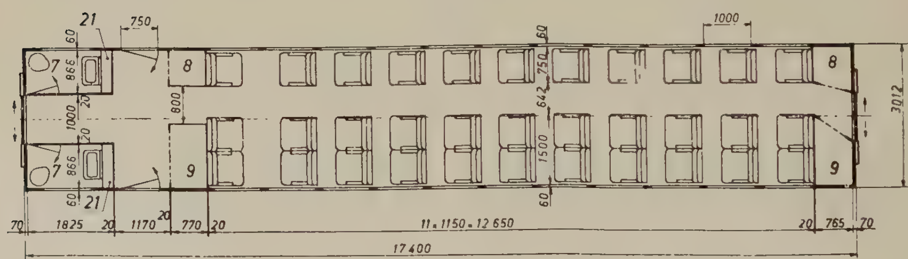


Fig. 14. — Large compartment coach.

7. W. C.-toilet.
8. Cloak-room.
9. Hand luggage racks.
21. Apparatus locker.

the pantry and the adjoining compartments mentioned above take up 10.96 m of the coach. The remainder of the coach (6 332 mm) consists of a passenger compartment with 14 seats. The length of the compartment is 2 100 mm. Tables can be put up between the seats for meals when the dining-car is too crowded. At the end of the coach there is a clothing locker (8) and another for hand luggage (9).

The restaurant-car (fig. 12) consists of a dining saloon 12.6 m long with 41 seats arranged 2 + 1. The centre corridor is 670 mm wide so that passengers have a seat 740 mm wide from which they can dine at ease. The motor power installed in the TEE makes it possible to haul up to 6 passenger coaches with a total capacity of 200 seats, so that it is necessary to provide as many seats as possible in the restaurant car. The design and arrangement of the restaurant car follow the general lines of those of the VT 08 long distance railcar. As an annex to the dining-room, there is a bar with room for about 15, on the same lines as that in the articulated sleeping-car rake. If necessary, some passengers can also have their meals there. In all, there are therefore 41 seats in the dining-car, about 8 in the bar and 14 in the passenger compartment, i.e. a total of 63 seats, so that the main meal can be served in three services.

Figure 13 gives a plan of the passenger coach with six compartments having 36 seats. The length of the compartment is 2.2 m. Each compartment has two rows of three upholstered seats about 700 mm wide. The windows of the compartments are fixed with double glass and are 1 400 mm wide.

The side corridor is 772 mm wide. The coach has a vestibule with swing doors opening inwards, a W. C. with a wash-basin (7) and a locker for luggage (9) and another for clothes (8).

Figure 14 shows a coach with a large saloon or open compartment of 33 seats (arranged 1-2) which can be extended. The space between seats is 1 150 mm, allowing of a comfortable resting position. Between the two rows of seats, there is a 642 mm wide central corridor. The arrangement is on the same lines as that of the articulated sleeping-car rake. The compartment is fitted with longitudinal luggage racks on each side for small luggage. Large luggage and clothes can be left in the special lockers. An entrance vestibule and two toilets with wash-basins complete the arrangements.

The designs shown in figures 8 to 14 form the bases of the method of construction of the different coaches and may yet undergo some modifications in detail before the final plans are approved. The plans therefore give the broad outlines of the probable form of the « Trans-Europ-Express » railcar of the Deutsche Bundesbahn.

The coaches used for the transport of passengers are equipped with air conditioning plant on the « Yetair » system of the Lahmeyer Etna Company, which has been tried out on the most recent sleeping-cars of the « German Sleeping and Dining-Car Company ». Each coach is equipped with its own air conditioning plant, the refrigerator group of which is housed under the false floor. The electric heating is fed from the 380 V system connected to the auxiliary Diesel-electric group of the motor unit. The Yetair heating or cooling elements are placed in front of the windows, the fresh air ducts being arranged along the side wall above the floor. The advantage of this air conditioning equipment lies in the fact that the hot or fresh air comes in directly in front of the window and consequently the passengers are not inconvenienced by pulsated hot or cold air as in the hot air heating systems used so far. Moreover the Yetair system does not necessitate any air conduits in the ceiling, which reduces constructional costs.

[625 .143 .1]

Photo-elastic investigations of rails,

by Dr.-Ing. Fritz Birmann, Minden and Dr. phil. Dipl.-Ing. Hermann Deutler, Münich.

(*Eisenbahntechnishe Rundschau*, No. 4, April 1956.)

The stress conditions in rail cross-section and fish plates may be determined by photo-elastic tests made with level specimens of plastic material. This will greatly facilitate decisions about the most suitable rail profiles.

Importance and application of photo-elastic investigation.

The strength of materials is nowadays often assessed by using photo-elastic methods for resolving the problems of stresses. This method uses the phenomenon by which transparent bodies become bi-refractory under the action of applied forces. This effect, which was discovered in 1816 by the English expert Brewster and formulated quantitatively by Neumann (1841) and Wertheim (1854) has been used for some fifty years for the measurement of stresses. Its application is particularly simple in the resolution of problems concerning plain forces. In this case an artificial resine model of the piece under consideration is made and illuminated whilst under vertical load by means of a light with circular polarisation. The resultant figures, a group of isochrome curves, are lines of equal changes of phase and show the distribution of stresses to the edges.

When use is made of a flat specimen for the resolution of problems relating to other shapes, it is, unfortunately, not possible to determine the *absolute value* of stresses at the extremes, but it is quite suitable for showing the *relative values* of these stresses. These are adequate when the question concerns only the comparison of different cross sections of beams.

This is the case in the various investigations described here which were designed to provide comparative information on stresses in railway lines when loaded. Although the problem is basically a three-dimensional one, plain photo-elastic measurement offers the advantage of providing clear solutions in a fairly simple manner.

Why is this a three-dimensional problem ? It must be pointed out that in the longitudinal direction the rail is neither uniformly supported nor uniformly loaded. There would be a plane problem only if the above two conditions were fulfilled and if the effects of temperature were not felt (fig. 1). In this case, in effect, there cannot be strains in a longitudinal direction which consequently means that stresses

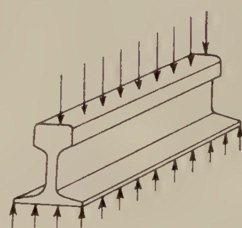


Fig. 1. — Rail uniformly loaded and uniformly supported.

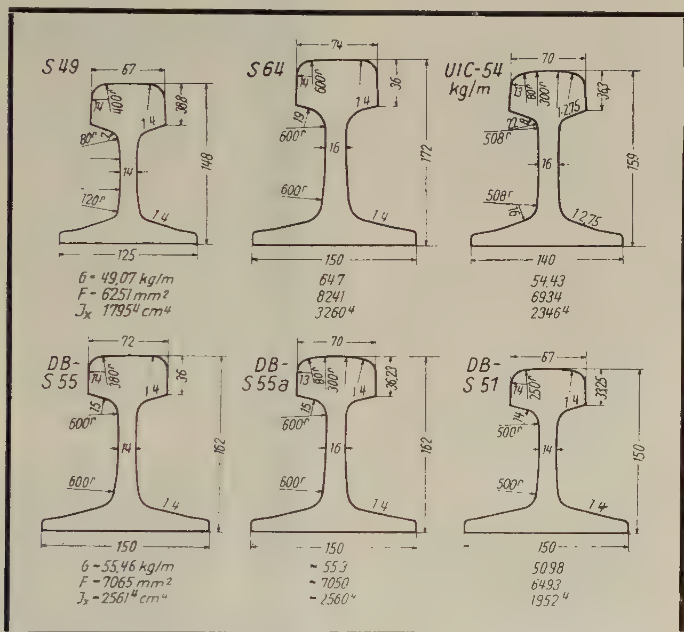
are set up only in the plane of the sections and in this direction each section of the rail can be used as required. As this is not so, it is easy to see that a test on a flat model cannot provide any information on the absolute value of the stresses. This, however, is of no importance, as we only need to know the relative values.

We are not concerned here with the physical basis of photo-elastic measurement.

This has been dealt with in numerous publications. It will be sufficient to mention that models have been cut from 10 mm (0.393 in.) sheets of VP 1527 resin supplied by Dynamit-Aktien-Gesellschaft (formerly A. Nobel & Co.) of Troisdorf and an interpretation made of the isochromes formed along the edges of the section on the rays of the lense system. Figure 2 shows how a trial is arranged.

The British Railways had frequently found cracks at the upper small radius (6.35 mm [0.255 in.]) flange of bull-head rails, these cracks being due to stress concentration. Photo-elastic investigation showed (1) (*) that the larger radius curves at the transition between web and head and between web and sole gave a better stress variation. In the adoption of the flat-bottom, 54 kg/m (119 lbs.) rail in 1948,

TABLE 1. — **Characteristics of rail sections considered.**



Purpose of the investigation.

The attempts made by the Rails Sub-Committee of the International Union of Railways to set up a basis for a standard rail showed the need for a method of comparing the various types of rail. The photo-elastic method and others were considered; the former because of the particularly clear results which it provides and moreover because this method had already been successfully used in England for establishing comparisons when replacing bull-head by flat-bottomed rails.

practical use was made of these results. Extensometer measurements on rails in position on the track confirmed the results obtained by photo-elastic measurements.

At the Brussels meeting of the Rails Sub-Committee of the U. I. C., on the 27th October 1953, it was decided to compare the S 64 rail of the German Bundesbahn with the normal S 49. When the S 64 profile was designed, account was taken, amongst other things, of experience gained in Amer-

(*) The numbers refer to the Bibliography.

ica with the amount of radiusing and shape of fishplates.

It was logical to examine this experience too by photo-elastic measurement. For this reason Dr.-Ing. F. BIRMANN therefore proposed that the Minden Central Office of the Bundesbahn should undertake experiments of this kind and these were subsequently carried out and interpreted by the Dipl.-Ing. H. DEUTLER at the Bundesbahn Testing Laboratory, Mechanical Section, Munich (*).

The test programme and its justification.

In addition to the S 49 and S 64 rails, the tests also included the I. R. U. (U. I. C.) standard profile rail of 54 kg/m (119 lbs.) and some proposed 51 (112 lbs.) and 55 kg (121 lbs.) rails designed by the Bundesbahn. Table 1 shows the various sections and their dimensions.

Before undertaking the tests, it was necessary to know what can had been given to the rails. On the Deutsche Bundesbahn 1 : 20 had, until recently, been generally used. At the time, however, 1 : 40 had become the practice and the I. R. U. (U. I. C.) were attempting to standardise this. It has numerous technical advantages as regards track laying; in particular, it simplifies track construction and track equipment when laid on sole plates. In switches, for example, it is possible to omit the intermediate RP 17 soleplate inclined at 1 : 40 used at the junction of vertical rails in track equipment to open track rails inclined at 1 : 20. With the track laid without soleplates, called H type, fixed by coachscrews or clips or elastic spikes, the wooden sleepers can be chamfered by 3 mm (1/8″) for the 1 : 40 cant. Similarly, the production of soleplates for track on concrete or steel sleepers becomes simpler and slightly cheaper with the 1 : 40 cant. In the United States, the 1 : 40 cant has been in use for more than 40 years and has given good results. Moreover, the cant of the rail does not in itself have a very important influence, because in service it is automatically and independently formed to some extent by the profile of wear, which is largely determined by the rolling stock. In order to reduce the number of tests to a reasonable figure, a 1 : 40 cant was used for all the rail profiles. In addition, some trials were also undertaken with 1 : 20 cant and with vertical basing, without however showing anything fundamentally new.

Fig. 2. — Method of applying the load for photo-elastic measurement.

For application of load, the following were used as representing those met in practice :

a) axial load (= new tyres on new rails);

b) off-centre load : point of application

(*) Dipl.-Ing. W. ZOTTMAN gave valuable assistance in this work. We record our grateful thanks to him.

TABLE 2. — **Tests on rails with 1 : 40 cant and main results.**

Rail	TEST 1	TEST 2	TEST 3	TEST 4
	APPLICATION OF LOAD			
	off-set towards outer edge		central	off-set towards inner edge
S 49	10 − 1,0 / − 1,0 / − 0,63 + 0,42 / + 0,58 / + 0,16	5 − 1,0 / − 1,0 / − 0,50 + 0,10 / + 0,30 / + 0,10	− 0,11 / + 0,22 / − 0,11 − 0,67 / − 1,0 / − 0,89	10 + 0,43 / + 0,65 / + 0,35 − 0,87 / − 1,0 / − 0,70
S 64	10 − 0,65 / − 0,60 / − 0,32 + 0,27 / + 0,27 / 0	5 − 0,62 / − 0,62 / − 0,34 0 / 0 / + 0,34	− 0,36 / − 0,22 / − 0,22 − 0,39 / − 0,39 / − 0,39	10 + 0,22 / + 0,26 / + 0,09 − 0,56 / − 0,61 / − 0,41
UIC-Profil	10 − 0,70 / − 0,76 / − 0,51 + 0,32 / + 0,38 / + 0,13	5 − 0,85 / − 0,97 / − 0,72 + 0,12 / + 0,24 / − 0,24	− 0,39 / − 0,13 / − 0,26 − 0,65 / − 0,78 / − 0,78	10 + 0,35 / + 0,50 / + 0,30 − 0,75 / − 0,81 / − 0,71
S 55	10 − 1,01 / − 1,08 / − 0,63 + 0,51 / + 0,38 / 0,25	5 − 0,97 / − 1,09 / − 0,60 + 0,24 / + 0,24 / − 0,24	− 0,13 / + 0,13 / − 0,13 − 0,78 / − 1,03 / − 1,03	10 + 0,50 / + 0,66 / + 0,40 − 0,91 / − 1,11 / − 0,81
S 55a	10 − 0,76 / − 0,70 / − 0,79 + 0,38 / + 0,32 / + 0,13	5 − 0,72 / − 0,72 / − 0,46 + 0,12 / + 0,12 / − 0,24	− 0,26 / 0 / − 0,26 − 0,52 / − 0,65 / − 0,65	10 + 0,30 / + 0,30 / + 0,20 − 0,50 / − 0,60 / − 0,40
S 51	10 − 1,14 / − 1,14 / − 0,70 + 0,70 / + 0,64 / + 0,45	5 − 1,20 / − 1,20 / 0,85 + 0,48 / + 0,36 / + 0,24	− 0,39 / − 0,26 / − 0,26 − 0,52 / − 0,65 / − 0,52	10 + 0,50 / + 0,50 / + 0,30 − 0,91 / − 0,91 / − 0,60

moved 5 and 10 mm (3/16″ and 3/8″) towards the outer edge (slightly worn tyres on new or old rails);

c) off-centre load: point of aplication moved 10 mm towards the inner edge (flange bearing on opposite rail).

Interpretation procedure.

As the tests did not provide for the determination of the absolute value of stresses, it was not possible to consider the whatsoever in a different rail. The normal German S 49 rail was made the reference rail and all other indications related to it, taking $\sigma_{max} = 1$. In the photo-

Fig. 3. — Isochrome image of S 64 rail, load off-set towards outer edge.

equation $\nu = \frac{\sigma_\nu}{\sigma_{max}}$ in which σ_{max} represents the maximum stress (whatever the symbol) in a rail selected at random, whilst σ_ν indicates the stress at any other point of the same rail or at any point elastic images, each interpretation relates to both sides of the rail at the following three points: transition from web to head, centre of web and transition from web to base.

For each of these points there is a num-

ber v so that for rails of identical load and differing profile, the influence of the shape is shown, and for rails of the same type, the influence of the excentricity of load is shown.

tions, only figures in the same column must be considered, not those accross as in condition of rail loading the S 49 is the datum for which the stress has been taken as equal to unity (in absolute value).

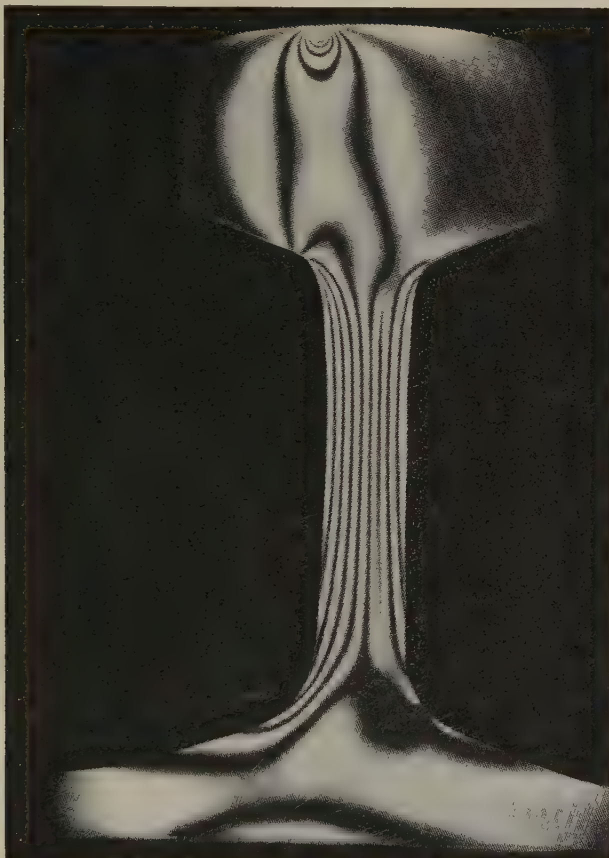


Fig. 4. — Profile of I. R. U. (U. I. C.) 54 kg/m (119 lbs.) rail, load applied as in figure 3.

Results.

Table 2 sets out the results obtained, arranged in the following way: in lines are the results obtained on the same rail section and in the columns are the tests made with the same point of application. Consequently, to compare several rail sections, only figures in the same column must be considered, not those accross as in condition of rail loading the S 49 is the datum for which the stress has been taken as equal to unity (in absolute value).

In every case the following observations can be made:

1) in the case of a load off-set as b) (10 mm [3/8″] excentric), the S 64 rail, because of the large radius at the junction of the head at the transition to the web (r = 19 mm [3/4″]) and the dimensions of

the web (16 mm [5/8″] thick) has end tensions one-third less (0.65 instead of 1) than the S 49. Figure 3 shows the isochrome lines of the S 64 rail;

2) the same applies to the I.R.U. (U.I.C.) rail with its three-centre radius (r = 8 mm [5/16″]) and 22 mm [7/8″]) junction and solid 16 mm thick web. The stress factor at the transition from head to web rises to 0.70 against 1 for the S 49 rail, and the stress factor in the web to 0.76. By comparison with the S 64 rail, it is remarkable to see that the peak stress is in the centre of the web (fig. 4), which is not in itself material, but is proof of correct design;

3) it is not surprising that the S 49 rail is subject to much higher stresses than the two designs mentioned above (fig. 5) because the junction with the head has a much smaller radius (r = 7 mm [9/32″]) and the web is thinner (14 mm [9/16″]). It will be seen in the other rail sections that the radius of the junction must not be regarded as the sole cause of high stresses. It must be noted that the German S 49 rail was designed to give a large volume for wear of the head and the distribution of stress was secondary to this. Moreover, experience has shown that the heavy stresses produced in the S 49 rail

Fig. 5. — S 49 rail; load applied as in figure 3.

are generally without danger, but where there is heavy rail corrosion in tunnels or industrial areas, it can be subject to longitudinal cracks in the head;

4) the German S 55 section having a head 150 mm (6″) wide and a web thickness of 14 mm (9/16″) was designed by the Bundesbahn Central Office at Minden for laying on wooden sleepers or on concrete sleepers without sole plates. The increased size of the head and foot, together with the increase in height compared with the S 49 must allow better utilisation and be advantageous because of the fitting of the articulated fish plate which has proved successful in the U. S. A. (2). The elastimetric design has given a stress image which is little different from that of the S 49 rail; as regards the latter it is essentially a consequence of the thinness of the web;

5) on the other hand, in the larger S 55*a* project, the effect of reinforcing the web from 14 to 16 mm is very favourable. Moreover, because of this strengthening, and the 2 mm reduction in the width of the head, the profile is very near to that of the I. R. U. (U. I. C.) 54 kg rail. The stress conditions are almost the same as those in the I. R. U. (U. I. C.) rail;

6) the S 51 version, also with a foot of 150 mm (6″) but a web of only 14 mm (9/16″) thickness has, from the numerical values of Table 2, a poorer stress distribution. Its use does not appear likely because

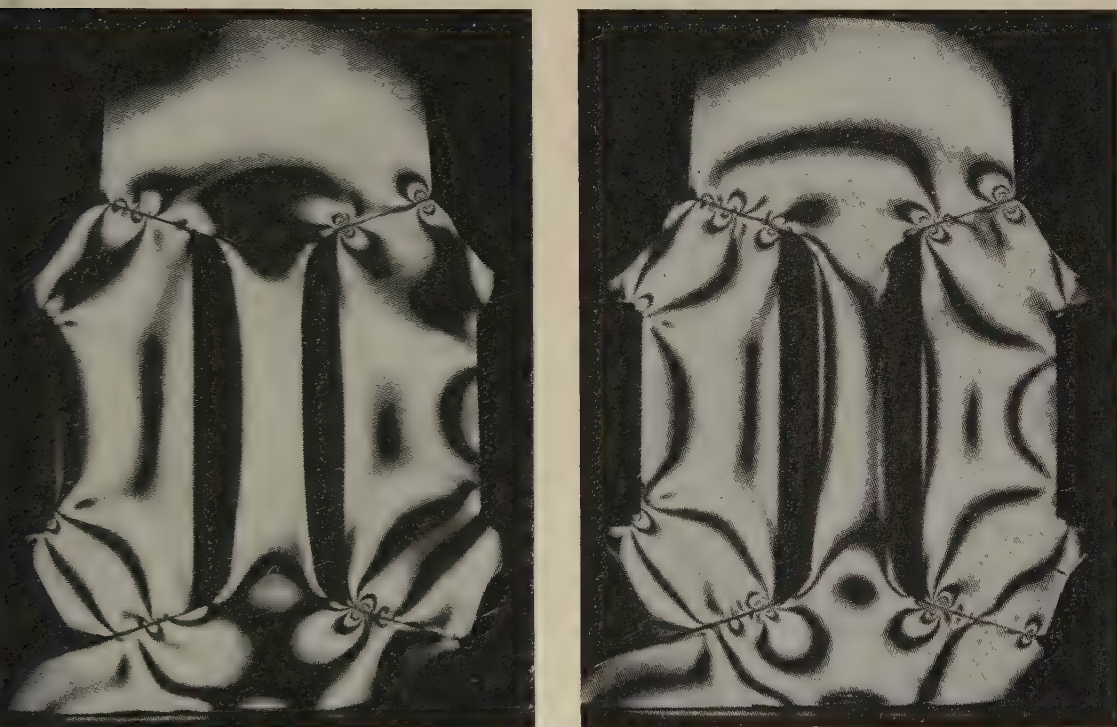


Fig. 6. — S 49 fishing without wheel load. Left: ideal tightening; right: one-sided tightening-flexing of web.

of technical difficulties in connection with rolling.

Fish-plated assemblies.

It appeared appropriate to complete the investigation by considering some fishplated assemblies. For this, the same methods of interpretation could be used as with free ends. The design of the plated assemblies presented some difficulty because the relatively large areas of contact between the fishplates and the rail made it impossible to obtain a clear image of the stress condition. This is all the more obvious since it concerns a hyperstatic bearing. The ideal case is that in which because of the bolting up of the fishplates, the web of the rail is stressed uniformly over the whole height, whilst any deflection of the web is an indication that the bedding of the two parts of the plate is not uniform. Figure 6 shows the various possible conditions; it shows the isochromes in the case of « ideal » and « non-ideal » bolting of a pair of fishplates on a S 49 rail.

In the wheel-load investigation, it was necessary to give the fishplates an « ideal » bolting before the wheel load could be applied. The ratio of wheel load to fishplate tightening was put at 10 : 8, corresponding to an actual wheel load of 10 tons and a total bolt tension of 8 tons. Figure 7 shows the effect of central and off-centre loading. It shows in particular that the pull at the fishplate turned towards the web of the rail is greater than in the central face of the web. It will also be seen that the fishplates bear on practically the whole of the bearing surface.

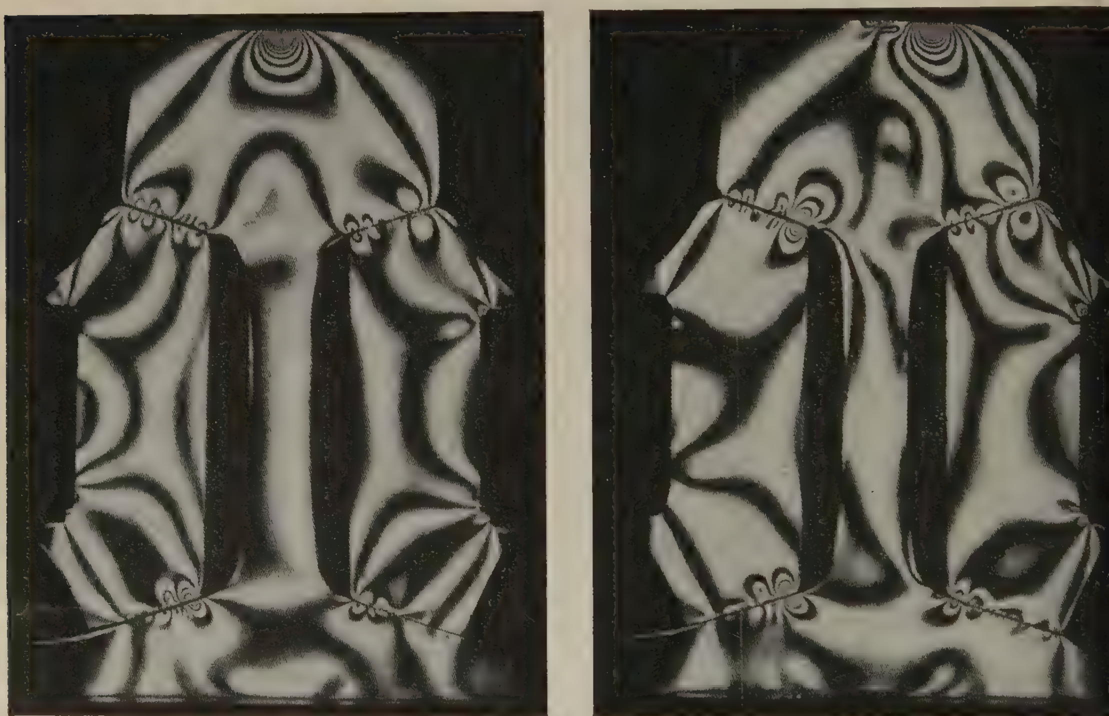


Fig. 7. — S 49 fishing with wheel load. Left: central load; right: off-set load.

Notes on investigations undertaken in other countries.

In the *U. S. A.* use had already been made of photo-elastic measurement (3) more than 20 years ago when investigating fractures at the junction with the head, experienced fairly frequently after the introduction of electric traction which entailed increased axle loads and speeds. This process was also used later in the design of heavy rail sections, and joint fittings. For many years in the U. S. A. special importance was attached to the smoothness of the transition from head to web.

In *Switzerland,* R. V. BAUD of the Federal Laboratory for Material Testing at Zurich found from photo-elastic measurements (4-5) confirmation of the results of his calculations which showed the prime necessity for well-designed transitions between head and web (making the best possible use of the web with uniform stress values on the end of the web).

In *Italy,* also, comparative trials were recently carried out, using photo-elastic measurement. The Italian State Railways also designed, as a heavy type, a 60 kg/m (132 lbs.) section and tested this and samples of Danish, Finnish and a 54 kg/m British flat-bottomed rail. In these tests, the excentricity of the load was 4.5 mm (11/64″). The Italian tests, too, showed that with a large radius junction to the head and the use of a thick web, a favourable stress distribution was assured.

Curvature of head of the rail and running of vehicles.

Given that there is a close relationship between the curvature of the head of the rail and the running of vehicles, we can draw attention to some features of the I. R. U. (U. I. C.) rail (fig. 8) in regard to the particularly favourable form of curvature of the head. In the centre is the least curved part, the width of which is 19 mm (3/4″) and the radius 300 mm (11 13/16″); on either side is a part about 15 mm (5/8″) wide with 80 mm (3 5/32″) radius followed by a transition of 13 mm (1/2″) radius to the cheeks of the rail. The S 49 rail on the contrary, designed 20 years ago, has a continuous curvature of 400 mm (1′ 3 1/4″) radius.

From information supplied by German and International Technical Committees, all rails after a certain period in service are subject to identical forms of wear.

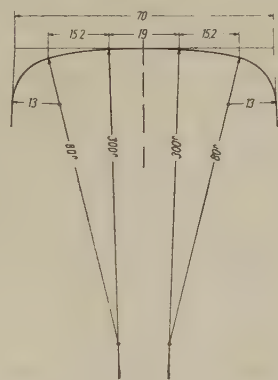


Fig. 8. — Head curvature of I. R. U. (U. I. C.) rail.

The head curvature of the I. R. U. (U. I. C.) rail comes very close to this form of wear and thus gives stable running from the start. It is intended to incorporate this curvature also in the rolling of S 49 and S 64 rails and to achieve it by grinding, planing or milling when restoring worn rails.

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[656 .254]

Radio and railway operation,

by M. Marchand,

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(*Revue Génerale des Chemins de fer,* June 1956.)

The important part played by radiotelephony in maritime and air transport is well known; but it has not been developed so much in the case of railway transport, chiefly on account of the fact that the railways have had since a long time ago very well developed telephone and signalling installations of their own.

Nevertheless, all the railways are very interested in the radiotelephony, and this interest was manifested in 1954 at the London Session of the International Railway Congress Association where one of the questions on the agenda dealt precisely with the use of the radiotelephony by the Operating Departments.

The *Revue Générale,* in October 1954, gave a brief report of the discussions on this subject, from which it was apparent that the United States are greatly in advance of the other railways since in that country there are already thousands of radio installations; this is due no doubt to the economic conditions prevailing in America which favour the use of all techniques capable of reducing — even to a small extent — their high labour costs; but it can also be explained by the actual characteristics of the operating which is assured essentially by liaison between the train dispatchers and the trains, without any intervention of the station staff, with very long and very heavy trains. Hence, for example, the interest of radio communication, the need for which is not felt in the same way in Europe : between dispatchers and guards, or between the guard and the driver of the train.

There are other fields however in which the operating conditions are similar, where the European Railways have recognised the advantages of radio, from the point of view of flexibility of working, of convenience and economy in carrying out the service : the installations made in Europe are perhaps not very numerous as yet, but their rapid development can be foreseen in the not too far off future.

Delicate and fragile to start with, radio equipment was very subject to frequent disturbances and breakdowns, which involved heavy maintenance costs. These major inconveniences have practically disappeared, and the radio industry has succeeded in building « railway » type equipment, i.e. having a very high standard of regularity of working, resistant to shock and dust and steam tight, essential characteristics of equipment that is to be installed on a locomotive.

The size and weight of the sets have been progressively reduced, and we have reached the stage of self-contained, transportable equipment, i.e. sets providing their own power from an accumulator whilst having a low weight of the order of 15 to 20 kg; any locomotive can now be equipped with a transmitter-receiver set without having to be provided with a generator before this can be installed.

Trials have been undertaken to perfect portable transmitter-receiver sets (2 to 3 kg) for the use of employees; such weights have already been achieved in the case of battery-operated radio, but this is a very expensive type, not economically workable in Europe.

The appearance in the industrial field of semi-conductors or transisters, which are taking the place of the classical types of

valves, will speed up considerably the progress made from the point of view of the working, and the reduction in size and weight... and very probably the price of the equipment.

As regards the quality of transmission, great progress has also been made thanks to the modulation of the frequency; the advantages of this are well known : insensitive to parasitic waves and much better qualities of reproduction.

On the other hand, transmission with modulation of the frequency is only possible with very short wave lengths and as a result have a limited field; this fact has prevented to date its extension into the sphere of radiodiffusion, but is not a drawback in the case of local radio services.

Consequently, radio is now a sufficiently regular and trustworthy method of transmission for it to be used by the railways.

The latter can therefore use it with advantage, especially to assure permanent communication with the locomotives or with the men on the line, with the sole reserve of being able to get allocation of the wave lengths which are much sought after, even in the relatively new field of « high frequencies », i.e. the metric waves which are entirely suitable for railway requirements.

The time has therefore come to deal with the installations in service on the S. N. C. F., in order to decide their possibilities at the present for the operating services [1] and to give some indications on future prospects.

Communication between fixed posts.

We are just mentioning these for the record, as the fact that there already are telephone installations would seem to make the development of radio communication between fixed posts unnecessary; to date they have only been used as a standby intended to make good under certain exceptional circumstances any deficiency or failure of the telephone services.

In this connection, in the immediate post-war period, the S. N. C. F. was allocated certain wave lengths to assure long distance telegraph orders until such time as the damaged telephone installations could be restored.

The communications established in this way on the Western Region between Paris and local headquarters and in the South-Eastern Region between Paris, Dijon, Lyons and Marseilles were of the greatest value, but they were suppressed as soon as the telephone system was restored.

In the same order of ideas, we may mention the equipment just installed on a single line in the Savoy : Saint-Pierre-d'Albigny to Bourg-Saint-Maurice; the traffic on this mountain line has considerably increased with the development of winter sports; the overhead telephone lines often break down however as a result of frost and snow storms, which leads to serious interruptions of the passenger services.

In order to make it possible, within the framework of the existing system, to continue to exchange safety dispatches from station to station (sectioning — safety prescription relating to the V. U.) radio communication has been installed between the stations.

This is done by means of very short waves, the wave lengths differing from section to section to avoid all risk of confusion; the length of the sections is about 10 km (6 miles) and transmission is excellent in spite of the very hilly character of the country.

Apart from periodic tests, the equipment is only used when the telephone services break down. The equipping of all the stations on the line will soon be completed (7 stations); this avoids the high cost of underground cabling all the telephone circuits.

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[1] The radio is also used apart from the operating by the hydro-electrical services (communications in mountain regions) and by fixed installations department (large working projects — communication between men some distance apart who must co-ordinate their work), etc.

Communication between a fixed installation in a station and shunting locomotives.

The most widely used type of communication and that which has been the subject of the longest trials — some dating from before the war — is that between the shunting locomotives in the large marshalling yards.

The output of the marshalling yard is directly bound up with the rhythm of shunting, and it is essential for the man at the hump to be able to regulate easily the speed at which the rakes being shunted are pushed over the hump.

The optical signals used for this purpose were based on the use of a necessarily summary code : moreover the signals inside the shunting sidings had to be multiplied so that there was always one visible to the driver in misty weather; in addition, the codes used were still more complicated when shunting was carried out with two engines working alternately.

Radio makes it possible to overcome all these difficultes, and practical experience has shown that it results in very great flexibility in carrying out the work and consequently increased output.

All the S. N. C. F. installations are bilateral, i.e. the driver can acknowledge the orders received. They are mostly with frequency modulation with a power at the aerial of 12 W which is sufficient for the distances involved, which are about 1 km. The S. N. C. F. at the end of 1955, had 46 marshalling yard radio installations, covering 100 locomotives, some of which are in use at the hump, and all these installations work very satisfactorily with a very small number of breakdowns (less than 1 % of the total working time).

This regularity of working has led in certain new marshalling yards (Toulouse-Saint-Jory, Tolbiac, Gevrey, Noisy-le-Sec, etc.) to the classical type of optical signals being omitted altogether, rudimentary standby measures being deemed sufficient (signals arms [ailes de manœuvre] or horns).

Mention may also be made of the Beziers installations where « portable » sets are used, as mentioned at the beginning of this note for equipping locomotives; this formula is economical, as it makes it possible to use any locomotive for shunting, or any locomotive with a very small amount of fixed equipment (antennae, bracket for the set).

In any case, radio deserves to be developed in marshalling yards as it renders appreciable services for a relatively small investment of capital; the cost of equipping a fixed post at the hump and three locomotives amounts to some 3.5 to 4 million francs.

Twenty new installations covering 50 locomotives will be completed during 1956.

* * *

Radio on shunting engines was originally intended to replace existing shunting signals, but in addition it has made it possible to assure invaluable communication with the shunting staff accompanying the engine for carrying out accessory jobs, such as the switching over of the marshalling sidings and picking up wagons that have got on the wrong siding.

Radio on an engine is then like a moving telephone the use of which can be invaluable for the shunting gang : driver and yard staff, and this great convenience has naturally opened up new perspectives for its use in other working places of all kinds, either to pass on information or orders to the gang or to collect rapidly the data needed for directing operations.

The first such installation was made at Paris-Lyons to assure permanent communication between the traffic controller and the Diesel engines responsible for taking away or bringing in the empty passenger rakes, which maintain a constant shuttle service on a 4 km long section between Paris and Paris-Conflans.

This radio link does not completely take the place of the signalling installations; it is a kind of « traffic » instrument making it possible to keep the shunting

gangs advised of the movements which are to be carried out and to let the head of the traffic department know at once of any incidents likely to affect the working of the service, etc.

The results is greater speed, which improves the fluidity of the services, especially at peak periods.

A similar installation is projected for Marseilles-Saint-Charles.

In a similar order of ideas, radio has been installed at the port of Dunkirk to assure communication with the engines serving the quays (*).

It is probable that similar installations will be made in other yards in which several shunting engines work scattered over them; first of all this will be done at the Guillotière yard where radio will make it possible to co-ordinate and improve the service to the numerous private industrial sidings south of Lyons.

It should be noted that in each of the yard installations, a single wave length is used to call the engines; each engine therefore receives advices and orders which do not concern it, but this does not lead to any particular inconvenience, and no need has been felt to install selective devices which would be complicated and expensive, since they would necessitate the use of several wave lengths or the use of selective call signals.

To sum up, radio on the shunting engines of marshalling yards and in large stations can be of the greatest service, and the departments concerned cannot be too strongly recommended to study its possibilities; for the record, in the year 1955 alone, the United States Railways carried out 100 installations covering the equipment of 400 locomotives.

(*) N. D. L. R. — See « Revue Générale des Chemins de fer », June 1956, p. 266: « Use of radiotelephonic communications for the control of shunting in the port of Dunkirk », by M. SPINNINGER.

Portable sets

(communication between the men and the head of the department or the shunting locomotives).

As we have indicated, portable sets are now the subject of research work and trials, and it can be expected that a working solution will be found in the near future.

The problem set to the makers is particularly difficult, because we require light weight transmitter-receiver sets, weighing not more than 3 kg with accumulators (batteries are too expensive), which will work for at least 8 hours and sufficiently powerful to work a small loud-speaker, as earphones cannot be used by men working the sidings who must be able to hear all traffic movements all the time.

As we are still in the trial period, we can only mention the possibilities of its application which is essentially its value in assuring communication between the control post of the marshalling yard and the men working in the yard, in zones which usually only have a few fixed telephones.

The transmission of information or finding out what they are to do means the men have to make some useless journeys; this leads to loss of time for the staff and above all to delays in carrying out the work which may result in delays in forwarding consignments and in the turnround of the wagons.

If, for example, an inspector finds a damaged wagon, it is desirable that he should be able to advise the control post of this fact immediately so that other inspectors can be alerted and sent to his assistance if the damaged vehicle can be repaired there, or other steps taken to deal rapidly with the wagon in question.

In the same way, the number taker can report without delay any wagon that has got out of place and consequently avoid any delay in making up the train.

As far as number takers are concerned, trials have been undertaken at Miramas to

see if radio will facilitate the preparation of the documents for the trains leaving (12 023); the number taker dictates all the details which are recorded at the office either directly or by magnetophone; the perfecting of the equipment has not yet reached a stage which gives conclusive results.

Another possibility for the use of such equipment though on a reduced scale is on the outskirts of the yard where the man at work can keep the goods office informed of the progress of the work: releasing a wagon which can be sent back to be reloaded, completing the load of a wagon for the preparation of the waybills, labels, etc.

Finally, portable sets could doubtless be used by the shunting foremen to give orders to the drivers when there are difficulties in the way of using optical signals — zones of poor visibility, lines on a curve, etc.

Consequently, portable radio sets could have a very extensive field of use, and it is probable that their use will develop very rapidly on the S. N. C. F. as soon as the makers have perfected types of equipment suitable for our needs.

Radiophonic communication with the trains.

Radiophonic communication with the trains is now possible on the material plane, at least in areas where the geographical conformation of the land does not give rise to difficulties, the presence of tunnels in particular forming an obstacle it is difficult to surmount.

The most recent technique consists of installing from place to place near the railway line fixed transmitter-receiver sets with an average radius of action of a few kilometres, which are all linked up with a central post; each of these sets then serves as a relay for communications exchanged with the trains passing through the zone in question.

The central post can, on the one hand, establish communication with a given train; on the other hand, it is linked up with the telephone network, so that passengers on the train can get into touch with any telephone subscriber.

Trials of this sort were carried out on the Charleville-Hirson line in 1955 and were very successful; it is probable that in a few years certain selected trains on the S. N. C. F., i.e. the trains more especially used by businessmen will offer this convenience; it is a question therefore of equipment which is intended to be an added inducement from the business point of view.

Some rather different trials, in so far as the object in view is concerned, will be carried out on the Dole-Vallorbe line which is shortly to be equipped with central control (i.e. control from a distance by the traffic regulator of the points and signals of the stations) to assure telephonic communication between the regulator and the train drivers.

We should mention here the use of radio to alert the drivers of trains of any unexpected danger: obstacle on the line, hot axle box, load out of place, etc. This is a suggestion put forward by members of the public who are astonished to see, for example that protection of obstacles is still assured by hand signals, flags, lanterns, fogsignals.

But if such a measure is to be effective, it would be necessary to equip not only all the locomotives but also all the men likely to discover any unexpected danger, i.e. the permanent way men, level crossing keepers, the stations and section signalboxes, etc.

Apart from the difficulties inherent in equipping on such a vast scale and the obligation to keep in a good state of repair equipment which will only rarely be used, we come up against the difficulty of the absence of any certainty that a radio signal has actually been sent and that it has effectively been received.

As a result if any incidents occur the sending out of a radio signal cannot make it possible to dispense with the use of the habitual measures taken, though in certain circumstances it might be possible to risk delaying their application.

Consequently, under present conditions of the technique, there is not much hope of radio being used to alert the trains of obstacles or unexpected dangers, improvements in this direction being concerned with :

— on the one hand, the use of torches with a very high luminous intensity, visible by day and night (drivers, level crossing keepers);

— on the other hand, equipping certain stations or signals boxes with means of acting on the signals to stop trains with hot axle boxes or shifted loads.

Radio adapted to safety communications.

The emission of a radio signal cannot in itself constitue a safeguard, but this particularity is nothing new to signalling technicians who have met and overcome the same difficulty in ordinary electric *installations.*

As is known in electric signalling a stop indication is always set up by cutting off the current permanently running through the conductor concerned.

In the same way, radio can only be considered as capable of assuring a safety function if the corresponding communication is the subject of a permanent emission corresponding to the « line clear » indication, the order to stop being given by the stopping of the emission.

This principle will be applied in certain local services, especially in the telecontrol of shunting engines such as the marshalling engines as a tele-controlled engine, unlike a shuntsman, cannot obey standby signals such as klaxons, or signal arms (ailes de manœuvre) capable of making good any possible breakdown in the radio.

It is possible to foresee variants, such as the permanent emission of a discontinuous signal, the cessation of which will bring about the stopping of the movement concerned, and it is in this direction that communications have been introduced in the outskirts of the Gare Saint-Lazare by means of portable sets between the head and tail of a train, to facilitate the reversing of the empty passenger rakes (*).

In this way, the permanent « radio » communication with a locomotive makes it possible to send a stop signal with every certitude, and by generalisation, it is possible to foresee the operation of a line without any optical signals, the line clear and stop orders being sent to the trains by a central post exactly informed of the position of all the traffic; this would merely be the equivalent in the « radio » field of the « cab signal » realised in America by the inductive effect of the track circuits on receiver equipment installed on the locomotives.

Other formulas can be applied, depending on asking for and being given the road, in such a way that an engine reaching a possible stopping place (entry to a section for example) would emit a radio signals and stop it if it did not receive by radio the authorisation to continue.

It would be premature to go into details about possible realisations which are the subject of thorough-going studies in comparison with other methods; the S. N. C. F. must, in fact, be ready to profit by all the new resources offered by a technique which is evolving very rapidly. Under present conditions, and ignoring the difficulties inherent in the circulation of engines not equipped, it does not appear that equipping a line with radio is worth considering, in view of the small savings that would result from doing away with the signals.

(*) N. D. L. R. — A detailed description of this installation is given in the article by M. DEULLIN : « Use of radiotelephony for the movement of passenger rakes between Paris-Saint-Lazare and Clichy ». « Revue Générale des Chemins de fer », June 1956, p. 270.

[656 .2 (42)]

Operating outlook on the Western Region, British Railways.

(From *The Railway Gazette*, November 23, 1956.)

The paper presented to the Institute of Transport in London on November 19 by Mr. S. G. HEARN, Chief Operating Superintendent, British Railways, Western Region, gives some details, many hitherto unpublished, of the progress made on the operating side towards the implementation of the railway modernisation plan. As is fitting in a paper by a Western Region officer, many of the examples are taken from that Region. The two main objectives which Mr. Hearn and railway operators in general have in mind are « a passenger-train timetable with a ' new look ' which is adequate to the needs of the public in frequency of service, punctuality, speed, safety, and comfort » and « a freight service which will establish and maintain entirely new standards in the provision of rapid, reliable, and safe transits ». These aims would be achieved through improved signalling and track layout; better permanent way; more up-to-date motive power, Diesel and electric; modern marshalling yards; continuous brakes on freight vehicles; and improved passenger stock of lighter weight. This last point, unless it refers to the « lightweight » Diesel sets, is an important conception deserving careful consideration by all Regional managements.

Passing to detailed examination of his points, Mr. Hearn believes that there will be an increasing speed of development of multiple-aspect colour-light signalling in association with extensions of automatic train control, long familiar in the Western Region, in its new form. The extension of the areas controlled from one signalbox should produce greater efficiency where trains converge on one central point and should also produce economies in operation. The central signalbox at York, North Eastern Region, is an example of what can be done in this direction. The application of power-working in these boxes reduces physical fatigue, and apparatus enabling as many movements as possible to be set automatically, or preselecting devices, can reduce mental fatigue. More intensive line occupation by the introduction of two-way working on one or more sections of line, particularly where there are marked traffic peaks in a particular direction at certain times of day, offers the possibility, with the necessary associated signalling, of ensuring that extra lines are not needed to accommodate increased traffic. Alternatively, it may give scope for economy by dispensing with one or more tracks. Station layouts will be re-designed to provide more facilities, particularly at terminals, for the in and out working of trains. This will enable the maximum economic utilisation of locomotives and multiple-unit trains to be achieved. Centralised traffic control has usually been coupled with certain Scottish lines when it has been considered for Britain, but Mr. Hearn now reveals that a considerable portion of the former London Midland (now Western Region) route from Shrewsbury to Swansea is in mind for this type of equipment. Much of the route is single track. The number of freight trains could be almost doubled with the use of C. T. C. and extra freight capacity could be made available between South West Wales, the Midlands, and the North without placing further burdens on the already heavily-occupied main route via Cardiff. To gain the utmost benefit from improved signalling, a general improvement in permissible speeds is needed on goods lines and through the junctions to them.

It is intended also to raise authorised speeds through some facing junctions on main trunk routes.

Re-alignments of track are being considered so that permanent speed restrictions can be modified. Mr. Hearn asks for patience to be exercised while this work, which, on the scale envisaged, must cause temporary difficulties, is carried out. The gradual life expiry of structures, bridges, and even, in some cases, the foundations of the track, is becoming pronounced at this stage in railway history. There are long stretches of line in the Western Region with foundations on clay, and heavy annual expenditure has been needed to keep the track in such places in a condition suitable for fast running. To tackle large-scale work successfully and economically with the very expensive track maintenance plant now used it is essential that the engineer be given long, absolute occupations, with consequent difficulties for the operating department.

Proposals for extensive use of Diesel traction in the Western Region are being considered under which the change-over might be made by geographical areas. In this way, with a complete change from steam to Diesel in each area in the shortest possible time, the difficulties and duplications of joint steam and Diesel working will be kept to a minimum. The first area may be the West of England. The whole of the motive power requirements of the Western Region could probably be covered by four basic types of Diesel locomotive and five basic types of multiple-unit Diesel train. The locomotives would comprise 350-HP shunters, 750-1 000-HP and 1 000-1 200-HP mixed traffic locomotives for local services, and 2 000-2 400-HP through passenger, parcels, and freight locomotives. The multiple-unit sets would comprise six-coach interurban express trains; three-coach cross-country, semi-fast trains; three-coach suburban trains; single-coach branch and connecting line units; and lightweight railbuses. The intercity services, which would have 60 first class and 208 second class seats, would have full buffet facilities, and the cross-country services would have limited buffet facilities.

As planned, the 1 000-HP Diesel locomotives would have a lower speed than those of 2 000-HP, but it is hoped that it may be possible to provide two gear ratios on the smaller locomotives to enable them to give assistance to the larger when required. Large-scale use of Diesel cars on suburban, cross-country, interurban, and some rural services is intended, and the immediate benefits, both from the users' and operators' points of view, are such that they will be brought into use throughout the Western Region as soon as the builders can deliver them. For longer journeys, using the inter-city and cross-country type of equipment, daily mileages of 500 per unit should be possible, but in suburban and short distance workings mileages will be lower. Rosters of less than 200 miles a day should be kept to the minimum for economic operation. Of the total time in traffic of multiple-unit Diesel trains, some 80 % can often be utilised in effective revenue-earning running, Mr. Hearn maintains, and there is also economy from the employment of one man only in the cab. Much thought has been given to the relative merits of Diesel multiple-unit operation and of locomotive-hauled trains for main-line use. The important factors to be considered are the ability to work the whole of the service with sets of similar formation; the need for special facilities, such as sleeping and Pullman cars; the extent to which trains must be cleaned or otherwise serviced at the terminals; the fluctuation in demand for a given service; the difficulties in making movements at the terminals; and the ability to find other work at times when there are no passenger demands.

The conclusion in the Western Region is that multiple-unit sets would be ideal for the shorter-distance, less heavily-loaded, main-line trains. Examples quoted by Mr. Hearn include Paddington to Oxford, Worcester, and Hereford; Paddington to Gloucester and Cheltenham; Paddington to Weymouth; Cardiff and Bristol to Portsmouth and Brighton in the Southern Re-

gion; Swansea and Bristol to the West of England. The formation of these trains would be similar to that of the others on the same route, and, if worked by multiple-unit stock with buffet or restaurant car facilities, it would be possible, in Mr. Hearn's opinion, to give a better and more economically worked service. Demand on these routes is reasonably constant and there are few special requirements to alter train formations. Much of the cleaning and watering could be done at the terminal platforms and the trains could turn round several times a day. Furthermore, there is little demand on these routes for Diesel locomotives to work freight and parcels trains during the night. On other services, where the formation of trains and demand for restaurant-car accommodation varies widely, and there are marked fluctuations in demand, it is considered that Diesel locomotives and conventional rolling stock are to be preferred. Western Region examples include London to Penzance; London to Swansea and West Wales; London to Birmingham, Shrewsbury, and Birkenhead; Manchester and Liverpool to Plymouth and the West of England. Certain of the trains, such as the « Cornish Riviera » and the « South Wales Pullman » have special characteristics, and others, at night, convey sleeping cars and parcels vans. The locomotives could be used economically during the night for freight and parcels working, a feature which will become more pronounced as more rolling stock is fitted with the continuous brake. A scheme prepared for the West of England showed that 30 Diesel locomotives could do work which would require 20 multiple-unit trains and 21 Diesel locomotives if the passenger working alone were segregated for multiple-unit operation.

Mr. HEARN gave examples of uneconomic track and station occupation by a single stopping train, and showed the number of other trains which could be run if even one such train could be cut out. On local services he expects to see, as a first stage, the retention of branch lines only as a medium for running freight services, with simplified signalling, and with the minimum of maintenance. It may be that two or more neighbouring branches or sections of line could be covered by one engine and crew in these circumstances, a method of working probably not feasible when passenger trains have also to be considered. In the next stage, even these local freight services may go when railhead concentration schemes have been fully considered and analysed. The substitution of road services for local freight trains and the disappearance of the unremunerative passenger train, with it attendant restritive operating characteristics, will do much to relieve the operating position.

The modernisation of marshalling yards and the simpliication of routes has been dealt with many times in these columns, but an example of the inter-Regional approach to the problem is given by Mr. HEARN, who speaks of the enlargement of a London Midland Region mashalling yard on a cross-country route to accommodate exchange traffic from the North to the Western and Southern Regions. This traffic is at present handled over the complicated — and expensive — network of junctions in the London area. An important development is that, by the use of electronic machinery, it should soon be possible to follow the movement of the individual wagon during transit. Teleprinters can be used to pass information forward from yard to yard. This feature will do much to meet the often-heard traders' complaint that once a consignment is loaded to rail it is lost sight of until arrival. Current opinion in this country favours a 21-22 ton wagon, but Mr. HEARN points out that some 88 % of the total freight tonnage carried on British Railways originates from private sidings, including most of the coal traffic. Half of the coal traffic, and 55 % of the total freight tonnage is delivered to private sidings. Not every trader is prepared to accept larger wagons, particularly the small coal merchant, who may find a large-capacity wagon, which he has insufficient labour to unload, an embarrassment.

[656 .211 .5 (42)]

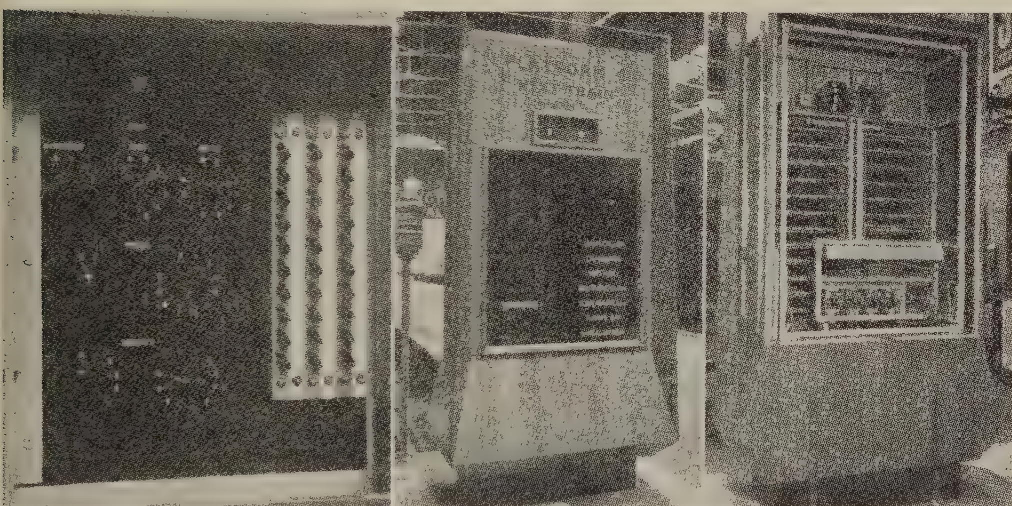
Experimental train indicator.

At Fenchurch Street.

(*Modern Transport*, December 8, 1956.)

Experiments have been taking place for some time on the Eastern Region of British Railways with various types of train indicators. In particular an indicator has been sought that can be changed quickly to show trains that leave at close intervals, each with different stops. For suburban indicators have certain limitations and in particular are difficult to read in sunlight.

With these requirements in mind the Eastern Region recently arranged with Siemens that an experimental indicator should be installed at Fenchurch Street. The indicator was planned not only to meet the



Train indicator at Fenchurch Street: Control panel; exterior; and, right, interior mechanism.

trains it is desirable to show all the stops rather than merely the destination; it is often an advantage if an indicator can be repeated in another part of the station, although still set from one control panel. At some stations it is desirable to work indicators for a number of platforms from one central point. For these requirements manually operated indicators are not altogether satisfactory. Even internally lit box problems at Fenchurch Street itself but to gain experience that would be useful in installing indicators at other places. In actual fact, the Fenchurch Street problem is a good one in that the trains leaving the station provide 130 regular combinations of stopping places; in addition, there are sometimes extra combinations required in times of emergency and provision has been made for this.

Control panel.

The control panel for the indicator is situated in a covered recess on the right-hand side of the indicator. Each train departing from Fenchurch Street has a code number which is set up on the top three rotary switches. Time of departure is selected on the bottom four rotary switches marked « hours » and « minutes ». Once set up on the control panel, the information to be displayed may be stored until such time as required. To make the display, it is simply necessary to operate the push-button at the extreme top of the control panel, when the appropriate information will automatically be displayed on the facia. Once the information is displayed, train departure details may be selected and stored for the next display, ready for operation of the « make display » switch when required. Information concerning special trains can be set up by manual operation of links on the right-hand side of the control panel.

The design of the equipment is a combination of three-faced long-slat type indicators and the automatic setting apparatus of the larger type of Siemens indicators, coupled with the motor mechanism. This motor revolves at about 3 000 r.p.m. due to the action of interrupter springs upon its two coils. One advantage of this kind of indicator is that once it is driven to a setting, it no longer uses power.

Economising electricity.

At Fenchurch Street train indications, on average, are not changed at intervals shorter than once in 15 min. This largely arises from the time needed to work a train into a terminal platform, unload the passengers and reload with passengers for the outgoing journey. For reasons of economy in electricity supply, it was decided to eliminate even the small standing load that would be involved by holding the setting relays operated during the interval in which the indication last set up remained untouched. A pulse circuit based on well-known principles was designed to ensure that upon completion of the setting up of a display, circuit elements would be disconnected and no power would thereafter be consumed until the occasion of the setting up of the next display.

The power for working the apparatus is obtained from a 50-V accumulator battery, supplied and installed, together with the associated charging equipment and wiring by the signal engineer of the Eastern Region.

[385. (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

Permanent Commission
of the International Railway Congress Association,

19, rue du Beau-Site, BRUSSELS.

XVIIth SESSION — MADRID (1958).

LIST OF QUESTIONS

for discussion

WITH THE NAMES OF THE REPORTERS.

1st SECTION : WAY AND WORKS.

QUESTION 1.

Problems presented by the ageing of bridges and viaducts. Long term effects of fatigue and corrosion in steel bridges and weathering of masonry.

Rational methods of maintenance of bridges.

Repair and strengthening.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Vietnam and Yugoslavia :

M. le Dr.-Ing. G. CIVIDALLI, Inspecteur en Chef Supérieur au Service de la Voie des Chemins de fer de l'Etat Italien; Piazza della Croce Rossa, Rome

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, Western Germany, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

M. F. LEMMERHOLD, Hauptverwaltungsrat, Referent für Brückenangelegenheiten, Hauptverwaltung der Deutschen Bundesbahn, Friedrich-Elbert-Anlage, 43, Frankfurt a. Main.

QUESTION 2.

Very long rails. Welding methods. Transport of long welded rails and necessary equipment for transporting, laying, fixing, ballast, tamping, etc.

Economic aspect of the question. Present tendencies.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. A. CRESPO MOCORREA, Chef du Département des Etudes et Reconstructions, Réseau National des Chemins de fer Espagnols, Madrid.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. F. JACKSON, Assistant Chief Civil Engineer (Maintenance), South African Railways and Harbours, Johannesburg.

2nd SECTION : LOCOMOTIVES AND ROLLING STOCK.

QUESTION 3.

Design and improvement of railcars and multiple-unit Diesel trains, as regards :

- **traction power equipment (location and suspension of the engine, type of transmission);**
- **characteristics of the construction (body and bogies);**
- **weight reduction;**
- **sound-proofing, heating, ventilation, air conditioning (supply of power required, advantages and drawbacks);**
- **buffer and traction gear. Intercommunication.**

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. l'Ing. Antonio da Silva Canavezes Junior, Division du Matériel et de la Traction, Compagnie des Chemins de fer Portugais, Estaçâo de Campanhâ, Porto.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, Western Germany, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

M. le Dr.-Ing. G.-A. Gaebler, Hauptverwaltungsrat, Referent für Dieseltriebfahrzeuge, Hauptverwaltung der Deutschen Bundesbahn, Friedrich-Ebert-Anlage, 43, Frankfurt a. Main.

QUESTION 4.

Comparative study of the periodical maintenance and repair of electric locomotives, in particular as regards :

— the wear of the tyres (influence of the wheel diameter, the axle-load, the speed, the type of bogies and eventually undulatory wear of the rails, etc.);

— the maintenance of traction motors and their transmission (flash at the collectors and methods of coping with it, use of roller bearings for the suspension of the motors and the hollow shafts, etc.);

— lubricants used (classical and such new types as bisulphide of molybdenum);

— wear of the friction strips of the pantographs.

Kind of work and periodicity.

Organisation of the maintenance and influence of common user (banalisation) of the locomotives.

Prime cost in relation to the type of equipment and the age of the engines.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. M. Viani Sous-Directeur, Chef du Département Electrique, Réseau National des Chemins de fer Espagnols, Madrid.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. K. J. COOK, Chief Mechanical and Electrical Engineer, Eastern and North Eastern Regions, British Railways, Doncaster.

3rd SECTION : WORKING.

QUESTION 5.

a) **Handling facilities in the goods depots for consignments in less than carloads, containers. General arrangement of the depots. Liaisons between the staff of the depot and the delivery services.**

b) **Railway problems regarding the introduction of general palletisation of packages.**

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. MARCHAND, Chef de la Division de la Réglementation et de la Sécurité à la Direction du Mouvement de la Société Nationale des Chemins de fer Français, 8, rue de Londres, Paris (9^e).

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Netherlands, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. DORJEE, General Manager of the N.V. Van Gend & Loos, Moreelsepark, Utrecht.

QUESTION 6.

When changing over to electric and Diesel traction for passenger train services, research of the principles which may lead to a rational and efficient organisation of same.

For this purpose to :

- **work out the social and economic needs and with this object in view, classify the passenger services according to the needs of the populations served, the distances, the volume of passenger traffic and its variations;**
- **fix, for each category, the traffic hours and advisable frequencies as well as the reasonable requirements of the public for comfort and speed;**
- **define the most suitable methods to draw up the timetables (including eventually regular interval train services) : choice of the type of train and rolling stock, fixing the runs.**

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. R. J. L. O. CARLIER, Ingénieur à la Direction de l'Exploitation de la Société Nationale des Chemins de fer Belges, 17, rue de Louvain, Bruxelles.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. G. F. FIENNES, Operating Superintendent, Eastern Region, British Railways, Liverpool Street Station, London, E.C.2.

4th SECTION : GENERAL

QUESTION 7.

Advantage of the use of high speed electronic apparatus for certain administrative work such as :

1) **the making out of pay slips;**
2) **traffic and stores accounts;**

3) the checking of the movement of empty and loaded freight wagons, thereby improving the distribution of rolling stock;

4) compiling more rapidly already existing statistics, thus having also the possibility of preparing new ones.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. B. H. de FONTGALLAND, Ingénieur Principal au Service des Etudes Générales de la Société Nationale des Chemins de fer Français, 88, rue Saint-Lazare, Paris (9e).

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics and the United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. Sten UBBE, Organisationsavdelningen, Chemins de fer de l'Etat Suédois, Klarabergsviadukten, 10, Stockholm C.

QUESTION 8.

Financing and conserving railway properties and assets.

Study and comparison for limited companies, partially state-owned companies and State Railways, of the financial means used for the normal renewal of installations and rolling stock.

Forms of amortisation and renewal, taking into account for the latter, the slow or speedy depreciation of the currency.

Reporters :

Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. W. KELLER, Chef de Section au Service de la Comptabilité Générale et du Contrôle des Finances des Chemins de fer fédéraux suisses, Hochschulstrasse, 6, Berne.

America (North and South), Australia (Commonwealth of), Austria, Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

M. le Ministerialrat Dipl.-Ing. V. FELDER, Finanzieller Direktor der Österreichischen Bundesbahnen, Elisabethstrasse, 9, Wien 1.

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5 th SECTION : LIGHT RAILWAYS AND COLONIAL RAILWAYS

QUESTION 9.

Experience obtained concerning the undulatory wear of rails.

— Damaging effects on the track, bridges, viaducts and tunnels, and on the rolling stock.

— Research into the causes of this kind of wear.

— Measures taken to avoid or to remedy it.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. L. PRIETO DELGADO, Sous-Chef du Département de la Voie et des Travaux, Réseau National des Chemins de fer Espagnols, Madrid.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. N. C. VOGAN, Chief Civil Engineer, New South Wales Government Railways, 19, York Street, Sydney.

QUESTION 10.

In view of the development of light railways, what are the means to be adopted in order to reduce the operating costs of these railways and what are the resulting basic amendments?

— Delimitation of electrification and dieselisation in relation to the traffic, capital costs and operating costs.

— Co-ordination between rail and road :

— Possibilities of mixed rail-road vehicles and of specialised vehicles for rail or road.

— Principles to be followed in regard to investment, in order to improve the returns from the capital available for the transport industry.

Reporters :

Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia :

M. le Prof. Dr. Ing. E. STAGNI, Inspecteur en Chef de la Motorisation Civile et des Transports concédés, Ministère des Transports, Piazza della Crosse Rossa, Rome.

America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaisia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories :

Mr. S. L. KUMAR, Director Research, Railway Testing and Research Centre, Ministry of Railways, Alambagh, Lucknow, India.

[**385.** (09 .2]

OBITUARY.

Sir Ralph WEDGWOOD, Bt., C.B., C.M.G.,

formerly Chief General Manager of the London & North Eastern Railway. Chairman of the Railway Executive Committee and Member of the Executive Committee of the Permanent Commission of the International Railway Congress Association.

Sir Ralph Wedgwood Bt., C.B., C.M.G., who died on September 5th, 1956, was Chief General Manager, London & North Eastern Railway 1923-39, and Chairman of the Railway Executive Committee, 1939-41.

Sir Ralph Wedgwood was born on March 2, 1874 and educated at Clifton and Trinity College, Cambridge. He entered the service of the former North Eastern Railway in 1896 at the age of 22, and in 1898 was transferred to West Hartlepool, where he served in the office of the Dock Superintendent for some years, latterly as Assistant Dock Superintendent. He returned to York as an assistant in the office of the General Traffic Manager, and, on the reorganisation of the staff of the Traffic Departments in 1902, was appointed District Superintendent, Middlesbrough. In 1904 he was appointed Secretary to the company, but shortly afterwards was re-transferred at his own request to the Traffic Department. In 1905 he was appointed Northern Divisional Goods Manager, Newcastle, and, in 1911, Assistant Goods Manager, York. He was appointed Chief Goods Manager shortly afterwards, and, in 1914, also undertook control of the work of the Passenger Department.

On the outbreak of war in 1914 he volunteered for service abroad, and with the rank of Major, R.E., for a time acted as D.A.D.R.T. in the Transport Establishment in France. In July, 1915, he was transferred to the Ministry of Munitions with the temporary rank of Lt.-Colonel. In October, 1916, he was appointed Director of Docks under the Director-General of Transportation (Sir Eric Geddes) with the temporary rank of Brigadier-General. He was awarded the C.M.G. in 1917 and a year later, the C.B. He also received the decoration of an Officer of the Legion of Honour and was appointed a Commander of the Belgian Order of the Crown.

He returned to the North Eastern Railway in June, 1919, and held the position of

Chief Goods Manager & Passenger Manager. In August, 1919, he added to these offices that of Deputy General Manager. He became General Manager at the beginning of 1922. He was Chairman of the Goods Manager's Conference of the Railway Clearing House in 1920, and frequently gave evidence on behalf of the railway companies before the Rates Advisory Committee.

When the L.N.E.R. was formed in 1923 he was appointed Chief General Manager of the new system. He was knighted in 1924.

Under the divisional system of management adopted by the L.N.E.R. divisional group managers had charge of group areas corresponding approximately to one or more of the separate pre-grouping railway compagnies. Sir Ralph WEDGWOOD thus became the only officer in Great Britain bearing the title of Chief General Manager. He retired on March 3rd, 1939. The following September he was appointed Chairman of the Railway Executive Committee. He held this position throughout the period of intensive railway reorganisation during the first years of the war and retired from it in Augut, 1941. He was created a baronet in 1942.

Sir Ralph WEDGWOOD was elected a Member of the Permanent Commission of our Association in 1925. He took a very active part in the proceedings of the London Congress (1925) of which he was a member of the Local Organizing Committee.

He attended also the Madrid Congress (1930) and at the Enlarged Meeting of the Permanent Commission held in Brussels (1935), he presided over the works of Section II dealing with the question : *The World Crisis and the Railways.* At the Paris Congress (1937), he was Chairman of Section I (Way and Works). He was appointed a Member of the Executive Committee of the Permanent Commission in 1938 and gave his resignation in 1939 following his retirement from his position of Chief General Manager of the London North Eastern Railway.

Thanks to his ceaseless activity and cheerful disposition, Sir RALPH was held in very high esteem by his colleagues of the Permanent Commission who will keep the best remembrances of him.

We wish to convey our sincerest sympathy to his family.

THE EXECUTIVE COMMITTEE.

NEW BOOKS AND PUBLICATIONS.

[**385** (08 (42)]

London Transport in 1955. — Report of the London Transport Executive. — One volume (6 5/16 × 9 in.) of 112 pages with numerous illustrations and tables. — 1956, London, London Transport, 55, Broadway, Westminster, S.W. 1.

The passenger services of the London region are the largest undertaking of the kind in the whole world. On the underground and overground lines (buses and trolleybuses), eleven million passengers are carried every day. At the end of 1955, the staff concerned had reached a figure of 86 795. The rolling stock consists of 4 032 vehicles used for the « underground » traffic and 9 747 vehicles used for the overground services.

This world famous report is worthy of study first of all because of the complete account that it gives of the year's working, and then because it stresses certain factors which characterise the centre in question: movement of the population, economic situation, social changes, kind of life.

The general considerations given in the note which serves as an introduction, show that after a recovery due to post-war circumstances there has been a decline in the traffic amounting to 10 % over the last five years. Nevertheless, the financial results have been better than during any year since 1949. A new tube is under consideration, the Victoria Line. A special chapter deals with the economics of this proposal.

Chapters II and III relate to the traffic and a study of the services organised. The report is very explicit on the causes of the decline in traffic, as well as on the steps taken to meet them. Amongst others is the expansion of television which has made journeys outside the peak hours still rarer.

Amongst the services offered to the public mention must be made of more frequent trains of limited size on the « underground » at slack periods, the introduction of buses operated by only one man, and express bus services on certain routes. To reduce the excess traffic at certain hours, a campaign has been introduced to stagger working hours, but to date this has not been very successful.

One of the great preoccupations of the Executive is « the congestion of London streets ». This upsets the regularity and speed of the bus services which consequently lose clients. The report makes some very interesting reflections on this question which also arises in other large cities.

A few fare increases have been accorded by the « Transport Tribunal » to cover increased operating costs. On the other hand, cheap tickets over certain routes at certain times of the day have proved popular with the public.

The chapter « Financial Results » distinguishes between the contribution of the Underground Railways and the bus services. This is a chance to recall the principles upon which the tariff policy is based and to stress the essential role of the metropolitan and urban lines of the British Railways.

Chapter VIII reports the improvements made to the equipment, both fixed and mobile, with the objectives in view of economy, safety and the comfort of passengers. At Camden Town Junction where 100 trains an hour pass, the operation of the points is now completely automatic. On the central section of the District Line electronic equipment controls the train speed, thus enabling the interval between trains to be reduced without danger.

The recruiting and training of the staff,

their pay conditions, and welfare, relations with staff organisation, all hold an important place in the report.

At the end of the volume there are statistical tables dealing with the functioning of the undertaking and its material and financial position.

E. M.

[**385** (09 (436)]

Die Österreichischen Bundesbahnen — Ein Spiegelbild Österreichischen Wiederaufstieges *(The Austrian Federal Railways — A symbol of the rebirth of Austria)*. — One volume (13 × 9 7/16 in.) of 70 pages, copiously illustrated. — 1956, Vienna, Österreichische Verkehrswerbung Ges. m.b.H.

This book was written on the occasion of the opening to traffic of the new station in the south of Vienna and the inauguration of electric traction on the Vienna-Gloggnitz, section of the southern line. The specialists authorised report on the amplitude of the tasks accomplished since the war by the Austrian Federal Railways to the benefit of the welfare of the country as a whole.

The bombardments and military operations of the war severely damaged the installations and rolling stock. That which survived, suffered from the lack of maintenance.

The first preoccupation was to make the vital lines usable again as quickly as possible. In spite of various difficulties, this work was carried out surprisingly quickly.

The reconstructions then put in hand had to be based on new conceptions. The same applied in the case of the working of the trains which had to be adapted to circumstances and this had repercussions on the lines and on the stations.

Amongst the work which had a happy influence upon the efficiency and economy of the transport services, electrification must head the list. This was begun again after the war according to a new programme. In particular, the southern line from Vienna to Gratz was included, the first section of which, from Vienna to Gloggnitz, has just been inaugurated.

The motorization of road transport and the complete renewal of the Viennese suburban transport dictated the general layout of the rebuilt Southern station. Its putting into service marks the end of one stage in the rebirth of the Austrian Federal Railways and indeed of the whole country. It is understandable that it was associated with the progress of electrification and solemnly celebrated.

The notes included in the book deal with various subjects relating to the operating of railways, especially those which most clearly show the will to modernize and rationalise.

In addition to electrification, much has been done in connection with the bridges, the permanent way, and the rolling stock.

The train services have been reorganised, and the tariff policy fundamentally revised. Mention must also be made of road transport considered as complementary to the railway or acting as a feeder service for certain lines. We must limit this enumeration which must of necessity be incomplete.

The results obtained after ten years of reorganisation are detailed in a note on the transport handled by the Federal Railways. One point emerges amongst the improvements made to the train services: the considerable increase in the mileage and transport units in the year 1955 compared with the year 1937.

Much space has been devoted in the second part of the book to the numerous industrial firms who have collaborated in the work of reconstruction. Information is given about their various activities accompanied by most interesting technical notes.

E. M.

[**385** (05]

Anuario de Ferrocarriles y Transportes por Carretera 1954-1955 *(Railway and Road Transport Annual, 1954-1955)*. — Published by the *Instituto del Transporte*, under the direction of M. Alfonso Imedio DIAZ, Doctor of Law, Assistant Manager of the Commercial Department of the R.E.N.F.E., Director of International Relations at the « Instituto del Transporte ». — One volume (6 5/16 × 8 1/4 in.) of 702 pages, illustrated. — 1956, Madrid, Instituto del Transporte, Plaza de las Cortes, 3, primero. (Price : 200 pesetas.)

The editions of this work show a tendency to follow each other at an ever increasing pace. It can be inferred from this that it has been favourably received in the circles concerned.

It is in fact a very useful book for many whose jobs bring them up against transport questions. This applies not only to transport undertakings but to the various public administrations who have to carry out controls, even as regards the general management.

All the ministerial departments on whom depends the proper working of transport from the point of view of economy, regularity and national security are represented. In the front rank is the Ministry of Public Works. This includes in particular the General Management of the Railways, Tramways and Road Transport Undertakings, and in addition the General Management of the Roads, as well as various official organisations of a consultative or executive nature.

The railways include first of all the Spanish National Railways (RENFE), then the narrow gauge lines some of which are State owned, some privately operated. To these must be added the Metropolitan Railways, the Tramways and other urban services. The railway is prolonged by the road transport undertakings co-ordinated with it.

At home, the list is completed by numerous firms who have business relations with transport.

For abroad, the list of the foreign railways and international organisations which are in liaison with the Spanish railways.

As regards legislation, a chronological list gives all the laws passed since August 1953 up to the end of 1955.

To facilitate reference, an alphabetical list at the beginning refers the reader to the passages dealing with the different functions concerned.

E. M.

[**656** (06 (43)]

Vorträge und Berichte des I. Verkehrwissenschaflichen Tages der Hochschule für Verkehrswesen Dresden *(Speeches and Reports of the First Field-day of the Science of Transport*, organised by Dresden Transport High School, 12/13 November 1954). — One volume (5 1/2 × 7 7/8 in.) of 150 pages, copiously illustrated. — 1955, Dresde, published by the « Rektorat der Hochschule fûr Verkehrswesen Dresden. »

The Dresden Transport High School organised in November 1954 a field-day devoted to the study of science in relation to transport. The object was to encourage the getting together of theory and practice, the former serving to guide the latter and this in its turn feeding and supporting the searchers.

The numerous experts who attended these meetings found in the communications and exchanges of opinion a means of extending their knowledge and the professionals invaluable guidance in carrying out their tasks.

Conscious of the fact that transport is of world wide interest, the organisors

attached special importance to as many other countries as possible taking part.

In view of the success of this field-day and the results achieved, it was decided to make it a permanent institution and to organise meetings of this kind every year.

This volume was published on the occasion of the second field-day in June 1956. It contains the text of the main lectures given, though the text has sometimes had to be shortened owing to lack of space. In addition, a certain number of the reports are summed up in the general review which ends the book.

The subjects dealt with cover very various fields.

There are several studies on slide-chairs, and in the case of rolling stock, another on using lignite for firing locomotives. A contribution to the general organisation of railways is furnished by a dissertation on the principles of a theory concerning transport currents. As regards safety, there is a synthesis on the intervention of the trains in freeing the routes. The traffic will gain in regularity and economy by the use of dispatching in the case of freight transport. Let us terminate this list by a note on the physical foundations for testing materials by ultra-sonic waves.

The reports summed up at the end of the book deal with subjects concerning the carrying out of the service. One of them deals with the elaboration of work standards in the shops of the Deutsche Bundesbahn.

It is expected that in the future the activities of these field-days will not be limited to railway matters but will also extend to other methods of transport.

E. M.

M. WEISSENBRUCH & Co. Ltd.
Printer to the King
(Manag. Dir.: P. de Weissenbruch,
238, chaussée de Vleurgat, XL)

PRINTED IN BELGIUM

Edit. responsible : P. Ghilain